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EVALUATION OF POLLUTION ABATEMENT TECHNIQUES APPLICABLE TO LOST CREEK AND BROWN'S CREEK WATERSHED, WEST VIRGINIA

Ackenheil and Associates Geo Systems, Incorporated

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Pittsburgh, Pennsylvania

APPALACHIAN REGIONAL COMMISSION

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PREPARED FOR

THE APPALACHIAN REGIONAL COMMISSION

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PREFACE

This study is one of a series of reports being prepared for the Appalachian Regional Commission for the development of an overall environmetal pollution abatement plan for the Monongahela River Basin with special attention to mine drainage. The Basin is an 18-county area encompassing parts of Appalachian West Virginia, Pennsylvania and Maryland.

These studies are being performed under an agreement between the Environmental Protection Agency and the Commission and are part of a larger EPA effort to deal with elimination and control of mine drainage within the watershed. The Commission's major responsibility in this interagency effort is to evaluate the economic development impacts of mine drainage and other pollution abatement which will include for planning purposes those engineering studies necessary to determine cost effectiveness among possible alternative approaches and to assess the full range of activities required to improve the environment within the Basin consistent with water and land use objectives. It is felt that if pollutants and other environmentally degrading problems can be alleviated, other public and private investments will provide greater opportunities to improve the economy of the Basin. The results of these studies then should suggest courses of action for selecting priorities for environmental and associated projects to Federal, State, and local decision-makers and the private sector as well as clarifying the Basin's potential for economic development.

SUMMARY

An investigation has been made of pollution abatement techniques applicable to the Lost Creek and Brown's Creek Watershed in Harrison County, West Virginia.

The primary objectives of the study were to evaluate applicable pollution reduction methods and provide recommendations as to least cost and best overall solutions to mine drainage problems in the Watershed. Study results are based on water quality data obtained during previous investigations and on supplementary data gathered during this study.

The principal conclusions which have been developed are as follows:

1. The water quality of Lost Creek and Brown's Creek has improved significantly over the past five years. Present levels of mine drainage in the Watershed are believed to have little net effect on the quality of water supply to the West Fork River and the Clarksburg Water Plant.

2. Four major drainage sources are now identified within the Watershed. These sources are estimated to discharge a combined 4800 lbs/day acid load and 600 lbs/day iron load to the principal streams.

3. Conventional surface reclamation and treatment are believed to be the methods best suited for correction of the existing mine drainage problems.

4. A least cost plan to achieve abatement has been developed. This plan involves an estimated capital expenditure of $680,000 and would provide an 80% reduction in acid and iron loads. The basic plan consists of surface reclamation at two locations and lime neutralization treatment at two additional sites.

5. A long term plan of abatement has also been developed. This plan gives consideration to associated long range environmental benefits to the Lost Creek - Brown's Creek area. Capital cost of the plan is estimated to be $1,760,000. Anticipated benefits include a 90% reduction in acid and iron loads, a reverse osmosis facility to provide a domestic water supply, a sewage treatment plant at Lost Creek to improve health conditions and enhance growth of the community, and esthetic improvements in other areas of the watershed.

It is further concluded that preliminary design information and additional stream flow data should be obtained prior to reaching final decisions on plant installations within either the least cost or long term abatement plans. Discussions are also required with various health and governing agencies relative to water supply and sewage treatment possibilities.

Obtaining capital and operating funds for various segments of the abatement plans may present some problems. Possible sources of funds are presented but additional investigations and discussions with prospective funding groups will be required in order to obtain commitments. Funds may be least difficult to obtain for surface reclamation work.

The possibility of installing pre-treatment facilities at the Clarksburg Water Plant has been explored but modifications at the plant will not result in improving environmental conditions within the Lost Creek and Brown's Creek Watershed. Desirable facilities at the Clarksburg Water Plant include additions for water softening and a means of handling sludge disposal.

Primary recommendations developed within the study are:

1. That a program be implemented as soon as practical to perform the described surface reclamation work in accordance with established priorities.

2. That detailed explorations be made relative to securing funds for treatment plant possibilities, with emphasis placed on pursuing the long term abatement plan for the Watershed.

3. That a program be initiated to obtain preliminary design data for possible treatment plant options.

CHAPTER I

INTRODUCTION AND PURPOSE

INTRODUCTION

The Appalachian Regional Commission (ARC) has been directed by the United States Congress to prepare a comprehensive environmental improvement program aimed at developing the economic potential of the Monongahela River Basin. The ARC program is to give emphasis to results achievable through the abatement of mine drainage pollution. This program is now being implemented.

This study, "An Evaluation of Pollution Abatement Techniques Applicable to the Lost Creek and Brown's Creek Watershed, West Virginia," represents one input to the total ARC program. The area of investigation is an extensively coal mined region located in Harrison County, a few miles south of the city of Clarksburg.

The West Fork River, a principal tributary of the Monongahela River, drains the entire study area. This area includes some 30 square miles. Figure 1 indicates the relationship of the study area to the city of Clarksburg, the West Fork River, and the total Monongahela River Basin.

Because of the proximity of Lost Creek and Brown's Creek to Clarksburg, the quality of these streams has some importance to the overall raw water supply for the city. In past years, especially during dry periods, acid mine drainage contained in these streams has caused operational difficulties at the Clarksburg Water Plant, located downstream on the West Fork River.

Previous studies of the mine drainage in the Lost Creek and Brown's Creek areas have been made. These studies have generally inventoried drainage

sources and have shown that problems are due to both deep mine and strip mine activities. The FWPCA gathered information in both the Lost Creek and Brown's Creek areas in 1965 and 1967. The results of these studies were eventually published in the 1971 summary report of the Monongahela River Mine Drainage Remedial Project. During the period 1966 to 1968, the Halliburton Company conducted a feasibility study and performed experimental field tests of various sealing techniques in the Upper West Fork River sub-basin. A second study initiated by Halliburton in 1968 was concerned solely with the Brown's Creek area. This later study, concluded in 1970, was aimed at locating hidden drift mine openings and obtaining a survey of total mine drainage pollution in Brown's Creek.

OBJECTIVE AND SCOPE OF INVESTIGATION

The principal objective of this investigation was to provide information on possible mine drainage pollution reduction activities which might be carried out in the Lost Creek and Brown's Creek watershed.

The main items of scope for the investigation were as follows:

1. Review past work and water quality information available for the Lost Creek and Brown's Creek watershed.
2. Supplement the water quality data where necessary.
3. Evaluate pollution abatement possibilities using volume reduction techniques.
4. Explore the alternative merits of installing mine water collection and treatment system(s).
5. Compare the effectiveness and costs of applicable methods.
6. Present a recommendation to the ARC as to a least cost solution to the mine drainage problem in the watershed.

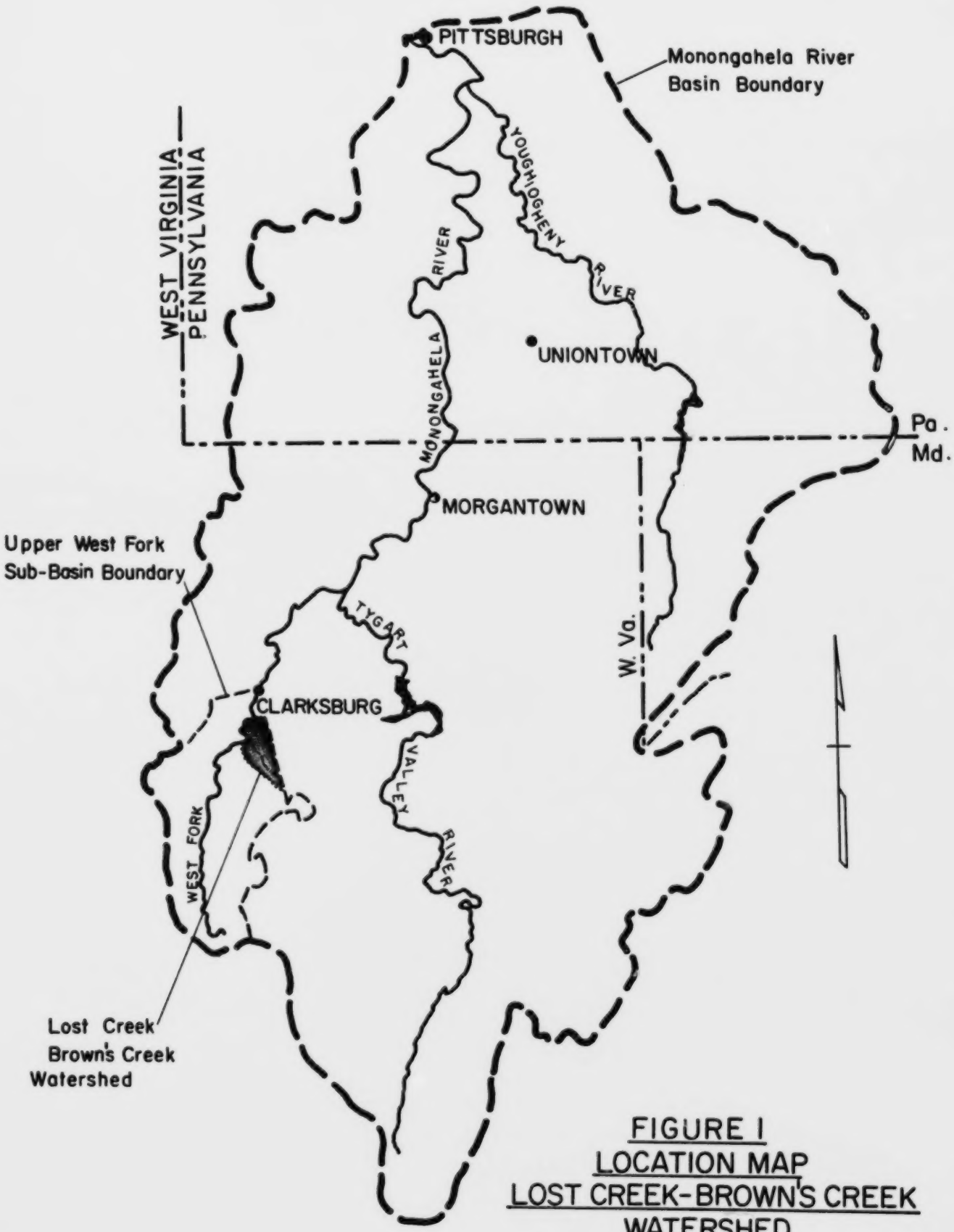

FIGURE 1
LOCATION MAP
LOST CREEK-BROWN'S CREEK
WATERSHED

7. Provide a recommendation as to the best overall solution to the mine drainage problem with consideration given to associated long range environmental benefits to the Lost Creek - Brown's Creek areas.
8. Investigate the feasibility of providing pre-treatment facilities at the Clarksburg Water Plant.
9. Investigate and present conclusions on the possibilities of non-public responsibilities for mining area restoration.
10. Determine the effect of current strip mining on Brown's Creek water quality.
11. Conduct a limited survey of users of Clarksburg water to determine attitudes on hardness in the public water supply.

CHAPTER II

IDENTIFICATION OF PROBLEM AREAS

REVIEW OF GEOLOGY AND MINING HISTORY

Previous investigations of the Lost Creek and Brown's Creek area have developed considerable information regarding topography, geology, and mining history of the area. The following data, obtained for the most part from previous studies, is considered important as a general review.

Topography

The Lost Creek and Brown's Creek Watershed consists of numerous hills and hollows with the slopes of most hillsides ranging from about 20 to 40 per cent. A minimum of "flat" land exists within the watershed. The majority of the level land occurs along the main courses of Brown's Creek and Lost Creek, with the larger portion occurring as alluvial flat land along the length of Lost Creek.

Geology

The exposed rock strata in the watershed are of Monongahela and Conemaugh age with the Monongahela series overlying the Conemaugh. The Pittsburgh Coal lies at the bottom of the Monongahela series.

Two geologic structures strongly influence subsurface drainage within the Lost Creek and Brown's Creek area. These are the Chestnut Ridge Anticline and the Shinston Syncline.

The Chestnut Ridge Anticline trends in a southwest-northeast direction and lies to the east of the Brown's Creek Watershed. This structure causes the Pittsburgh Coal to be at a higher elevation in the adjacent Elk Creek Basin and most likely results in significant drainage via

mine complexes from this basin into the Brown's Creek area. A pictorial representation of subsurface structure for the Pittsburgh Coal is provided on Figure 3 of Appendix C.

The Shinston Syncline runs northeasterly through the Lost Creek area and then plunges to the north through the Brown's Creek area. The Pittsburgh Coal is at a slightly higher elevation in the adjacent Duck Creek Basin. This condition results in some drainage from the Duck Creek Basin east into the Lost Creek Watershed.

Mining History

The coal seams of greatest economic importance in the watershed are the Redstone and Pittsburgh. Concurrent mining of these horizons frequently occurs since the distance between the Pittsburgh and Redstone is normally 40 to 50 feet. Except for isolated occurrences in the Brown's Creek area, the Redstone is generally of commercial thickness and purity only in the Lost Creek area.

Coal thickness in the area varies from zero to six feet for the Redstone and from about five to nine feet for the Pittsburgh. Where not absent, the Redstone Coal is usually of good quality. The Pittsburgh Coal is of course the most valuable economic stratum of the Monongahela series.

The Pittsburgh and Redstone seams have been extensively mined in the watershed by strip, auger and drift mining methods.

Drift mining began in the region in the early 1900's and continued through the 1940's and years subsequent to World War II. Drift mining has occurred as both primary (room and pillar) and secondary (pillar removal) operations. The primary mining generally resulted in removal of some 30 per cent of the mineable coal and secondary methods often removed an additional 50 per cent. The secondary mining operations created large void spaces at mine levels with resultant roof falls and, in some cases, surface subsidence.

Strip mining and augering were very common in the watershed during and immediately following World War II and have continued on a more limited scale in recent years. In many instances, the strip mining and augering have intersected underground mines and have provided additional openings for air circulation, water entry, and drainage. This condition has been a significant factor leading to the mine drainage problems in the area.

Many of the strip mines in the Lost Creek and Brown's Creek areas have been reclaimed or partially reclaimed over the years. In late 1972, reclamation was still in progress in specific areas. It is estimated that 70 per cent or more of the justifiable reclamation has now been completed within the study area.

SUMMARY OF PREVIOUS STREAM QUALITY DATA

Study of the water quality of the Lost Creek and Brown's Creek Watershed was initiated by reviewing the information obtained in previous investigations of the area.

Brown's Creek

The Halliburton investigations of the Brown's Creek area included the gathering of stream quality data during the 12 month period from October 1968 to October 1969. Stream quality information was obtained at five sampling points along the main course of Brown's Creek. Water quality data was not reported for individual tributaries of Brown's Creek.

The sampling locations selected and numbered by Halliburton are shown on Figure 4 of Appendix C. The number designation initiated by Halliburton, e.e., SP-1, SP-2, etc., has been retained for purposes of this study. SP-1 is located near the mouth of Brown's Creek; higher numbers indicate upstream locations.

The Halliburton water quality information for Brown's Creek is presented on Table I of Appendix A. A summary of pertinent data is as follows:

Station	Avg. pH	Flow GPM	Net Acid Load Lbs/Day	Iron MG/L
SP-1	6.2	1400	958	8.9
SP-2	5.7	1084	1086	11.3
SP-3	6.7	781	191	7.9
SP-4	5.0	452	730	3.9
SP-5	6.5	289	(70)	1.9

Parentheses Indicate Net Alkaline Load

The variation of pH and net acid load along the main course of Brown's Creek provides a general indication of the location of the more severely polluted tributaries. The tabulated data also suggests that noticeable dilution and/or neutralization occurs over certain lengths of Brown's Creek.

The FWPCA investigation of the Brown's Creek area in 1965 and 1967 consisted principally of study of individual mine discharges and an inventory of spoil areas, gob piles, etc. Isolated pH measurements and flow rates were reported for individual mine discharges. A single sampling and flow measurement at the mouth of Brown's Creek was also obtained, but stream quality profiles of Brown's Creek and its tributaries were not developed.

Lost Creek

The Lost Creek data available for review at the start of this investigation consisted solely of the FWPCA data gathered in 1965. As with the Brown's Creek area, the information included isolated pH measurements and flow rates at specific mine discharge locations. A water quality profile of the Lost Creek Watershed was not obtained.

SUPPLEMENTARY WATER QUALITY DATA

A review of water quality information obtained during earlier investigations indicated a need for supplementary data in order to complete the objectives of this study. It was determined that additional data were required to provide:

1. A water quality profile for Lost Creek to permit overall evaluation of the stream.
2. Water quality parameters for tributaries of both Lost Creek and Brown's Creek to enable definition of major problem areas.
3. Confirmation of water quality improvement for Lost Creek and Brown's Creek suggested by data made available by the Clarksburg Water Board.

Details on the supplementary data gathered and discussion of results are presented in the following sections.

Brown's Creek

The supplementary investigation of water quality in the Brown's Creek area consisted of selecting stations at the mouths of main tributaries, recording stream flows and obtaining samples at these stations, and developing water quality profiles along specific tributaries where water quality problems were suspected. For purposes of verification, stream flows and samples were also obtained at the original five Halliburton stations along Brown's Creek.

The locations of all stations in the Brown's Creek area are shown on Figure 4 of Appendix C. Stations added to the original Halliburton locations were SP-1A, SP-2A, SP-3A, SP-4A and SP-4B, all of which are located at the mouths of main tributaries to Brown's Creek.

Flow rates and water samplings were made in July and August of 1972. Samples were tested for pH, acidity, alkalinity, iron, sulfate, aluminum and manganese. All supplementary water quality information developed for the Brown's Creek area is summarized on Table 2 in Appendix A.

Analysis of supplementary data of Brown's Creek, together with information developed previously by Halliburton, indicates the following:

1. The spot check of stream flows along the main course of Brown's Creek shows flow rates at the time of measurement to be within the range of the 12-month average values calculated from the published Halliburton information.

2. The supplemental data suggest a significant improvement in the quality of Brown's Creek water during the period from 1968-1969 to 1972. The recent data show Brown's Creek to be alkaline over its entire length, whereas the 1968-1969 data indicate the main stream to be alkaline only at its upper reaches. A comparison of the 1968-1969 and 1972 water quality data is provided in Table 3 of Appendix A.

3. The water quality improvement indicated by the recent data is consistent with the trend of monthly data (July 1971 to August 1972) collected by the Clarksburg Water Board. The Water Board data, based on samplings at the mouth of Brown's Creek, is summarized on Table 4 of Appendix A.

4. As suggested by the data of Table 2 in Appendix A, the tributary which appears to contribute the majority of pollution to Brown's Creek is that tributary defined at its mouth by sampling station SP-3A. This stream flows east toward Brown's Creek in the vicinity of Alpha Penn Road. Lesser problems seem to be associated with certain other branches of Brown's Creek; these are discussed in a subsequent section of the report.

Lost Creek

As pointed out previously, a water quality profile for Lost Creek was not available at the initiation of this investigation. Thus,

the supplementary data obtained for this watershed represents the only information of this nature available for detailed study.

A total of 17 stations were selected for sampling and flow measurement along the main course of Lost Creek and at the mouths of major tributaries. The seven stations located along the main course of Lost Creek were LC-1, LC-2, LC-4, LC-8, LC-13, LC-14 and LC-15. All station locations are shown on Figure 4 of Appendix C.

Measurement of stream flows and water samplings were made in July and August of 1972. All samples were tested for the same water quality parameters as tested for Brown's Creek. The results are provided on Table 5 of Appendix A.

A summary of average water quality information obtained for stations located along the main course of Lost Creek is as follows:

Station	Avg. pH	Flow GPM	Net Alk. Load Lbs./Day	Iron MG/L
LC- 1	6.4	2800	698	0.2
LC- 2	6.1	2678	1100	0.3
LC- 4	6.2	2214	79	1.0
LC- 8	6.4	1025	394	0.1
LC-13	6.9	371	116	0.2
LC-14	6.5	347	120	0.5
LC-15	6.3	178	79	0.8

The above profile of Lost Creek water quality suggests that the stream remains in an alkaline condition over its entire length, assuming that the short sampling period is representative of "average" conditions. The indication that the Lost Creek water quality is reasonably good coincides with data gathered by the Clarksburg Water Board (See Table 4 in Appendix A).

Additional comments pertinent to the quality of water in the Lost Creek area, best reviewed in conjunction with the data presented in Table 5 of Appendix A, are as follows:

1. The third and final measurement of flow rates in late August 1972 showed a significant reduction over previously obtained flow rates in Lost Creek. Although better than average rainfall may have influenced previous flows to some degree, discussion with a number of residents in the Lost Creek area indicated these very low flows to be unusual. The typical response from those residents questioned was that they had seldom seen Lost Creek and its tributaries at such a low stage of flow. For purposes of continuing our investigation, it was assumed that these low flows for Lost Creek were not representative of "average" conditions.

2. With one notable exception, all tributaries of Lost Creek appear to be alkaline, at least at their mouths prior to entry into Lost Creek.

3. The tributary denoted by Station LC-4A appears to be the only major polluting stream entering Lost Creek. This branch significantly reduces the net alkalinity of Lost Creek immediately downstream but a strong diluting action is evident further downstream.

Special Area - Source 62062

Prior to obtaining supplementary water quality data for the Brown's Creek and Lost Creek areas, discussions were held with personnel of the Clarksburg Water Board for the purpose of obtaining definition of the West Fork water quality problems as related to the Clarksburg Water Plant. Within these preliminary discussions we were made aware of a major acid mine discharge which flows directly into the West Fork River within the area between the specific boundaries of the Lost Creek and Brown's Creek drainage areas. (See Figure 4 of Appendix C).

This discharge is designated as Source 62062 according to the mine classification system used in the original FWPCA Monongahela River study.

The source was field surveyed and it was concluded that the discharge was a major offender and would require sampling and analysis. Thus, flow rates and samplings were made for Source 62062 in conjunction with the gathering of the Lost Creek and Brown's Creek data. The resulting water quality data for Source 62062 is provided on Table 6 of Appendix A. A summary of the pertinent information is as follows:

Source	Avg. pH	Flow, GPM	Net Acid Load Lbs./Day	Concentration Iron, MG/L
62062	2.6	450	2176	69

Additional discussion of Source 62062 is presented in the following section of this report.

Effect of Sewage Discharges

Approximately 95% of the homes in the Lost Creek and Brown's Creek area dispose wastes directly into nearby streams. The question which arises is: "What masking effect does household sewage have on the recorded stream qualities, i.e., is the acid mine drainage problem actually worse than indicated?"

On the basis of preliminary field data obtained and some limited laboratory experimentation, it is concluded at this time that the sewage effect on the Lost Creek and Brown's Creek water qualities is probably minimal. The basis for this conclusion is the following:

1. Domestic sewage normally is neutral or slightly alkaline and generally exhibits an alkalinity only slightly greater than the water supply from which it is derived.

2. The alkalinity in sewage is due to ammonia while the acidity in acid mine drainage is due to sulfuric acid. Because of the relative strengths of these solutions, large amounts of ammonia are required for neutralization of the acid. This can be shown experimentally by a sulfuric acid-ammonia titration.

3. The amounts of sewage discharged into the area streams are generally small relative to the total stream flows recorded during our investigation.

4. A field water quality profile was made on tributary SP-2A where known sewage discharges occur. Although the long-range effect on Brown's Creek could not be assessed, no neutralization effect could be observed along SP-2A downstream of the sewage inlets.

PROBLEM AREAS IDENTIFIED

The water quality information available from previous investigations and all supplementary data obtained during this study were evaluated to identify major problem areas in the Lost Creek - Brown's Creek Watershed.

Problem tributaries were initially selected on the basis of their net influence on the water quality profiles of Lost Creek and Brown's Creek. Investigation of specific tributaries was then made to define the actual sources of difficulty.

Within the entire watershed, three tributaries were found to be causing the majority of water quality deterioration to Lost Creek and Brown's Creek. These are the streams identified at Stations SP-3A and SP-4A along Brown's Creek and Station LC-4A along Lost Creek. One additional problem area identified was Source 62062 which is neither a tributary of Brown's Creek nor Lost Creek, but drains directly into the West Fork River. A detailed description of each major problem area follows.

SP-3A - Brown's Creek Area

As indicated by the data of Table 2 in Appendix A, the SP-3A tributary is by far the principal contributor of pollution to Brown's Creek. Prior to entering Brown's Creek, the tributary shows a pH of about 2.5, net acidity of 400 to 500 mg/l, and variable but high iron content--12 to 55 mg/l. Depending upon flow rate, the stream may discharge anywhere from 800 to 1900 pounds of acid daily into Brown's Creek. Average net acid load is estimated to be near 1400 lbs/day. The supplementary data gathered indicates this may represent over 95% of the net acid load received by Brown's Creek.

The SP-3A tributary flows east into Brown's Creek in the vicinity of Alpha Penn Road. Approximately 500 feet from its mouth, the stream branches northwest and southwest. The source of the SP-3A pollution is found at the headwaters of these two branches.

Acid mine drainage emits from four abandoned drift mine openings at the origin of the northwest branch. These openings were designated as 40079-1, 40079-2, 40081-1 and 40081-2 by previous FWPCA study. Two of the openings were formerly sealed but are now discharging acid mine drainage. Down-slope from the mine openings, poor surface conditions exist due to the presence of gob and spoil material. Above the deep mine workings some subsidence areas exist. The combined drainage of the four deep mine discharges shows a pH of 2.3.

The problem source along the southwest branch is abandoned drift mine opening 40085. The discharge from this opening has a pH of 3.3. This acid flow joins an alkaline discharge (pH of 7.6) which results from overflow of an impoundment located upstream at strip mine area 40084. The combined flow of the southwest branch, prior to joining the northwest branch, shows a pH of 3.5.

SP-4A - Brown's Creek Area

The Hutchison Hollow tributary referenced as SP-4A also discharges from the west flank of Brown's Creek. The supplementary data collected do not indicate that the stream contributes net acid to Brown's Creek; however, it is probable that the stream is a slugger (200 lbs/day estimated).

This is strongly suggested by the Brown's Creek profile data compiled by Halliburton. The data of Table 1 in Appendix A indicates a significant deterioration in water quality between Stations SP-4 and SP-5 where SP-4A enters the main stream.

The SP-4A tributary is considered a major problem not only because of its assumed s'ugging tendencies but also because the tributary first gives Brown's Creek its discoloration. Brown's Creek is relatively clear prior to entry of the SP-4A tributary. The discoloration caused by SP-4A is believed due to a combination of iron carried intermittently by the stream and continuous flushing of sediments which line the stream channel.

The origin of the SP-4A tributary consists of drainage from three drift mine entries at 40064. The entries are partially closed but drainage (pH 5.8) occurs through spoil material piled about the entrances. Gob covers much of the area in the vicinity of the drift openings. Further downstream the drainage parallels a refuse covered access road. The surface condition of the entire area is believed to contribute heavily to the apparent slugging action.

LC-4A - Lost Creek Area

The LC-4A tributary flows east into Lost Creek near the community of Rider. Available water quality data shows this stream to be the only acidic discharge into Lost Creek (pH of 2.7, acid concentration of 250 mg/l, and net acid load of 500 to 1500 pounds daily dependent upon flow). Average net acid load is estimated at about 1000 lbs/day.

The water quality problem of LC-4A is believed to be principally a result of refuse material which the stream encounters along its path toward Lost Creek. At the upper reaches of the tributary, the flow originates from three impoundment areas but is essentially alkaline (pH of 5.7). At a distance of some 600 to 700 feet from Lost Creek, the stream passes through an extensive coal refuse area near a former coal preparation plant facility. Immediately downstream of this plant area, the LC-4A tributary shows a pH of 3.4. Additional seepage over and through spoil material and into the stream occurs further downstream prior to entry into Lost Creek.

Source 62062 - West Fork River

Source 62062 is a deep mine discharge directly into the West Fork River between Lost Creek and Brown's Creek. According to Clarksburg Water Board personnel, the discharge has been a troublesome one for many years.

Water quality parameters on Source 62062 show pH of 2.6, acid concentrations of approximately 400 mg/l, and acid load on the order of 2000 pounds per day.

The location of the discharge and study of the subsurface coal structure suggests Source 62062 drains a large deep mine complex which extends into the Lost Creek basin.

Other areas within the Lost Creek and Brown's Creek Watershed cause some difficulty with respect to water quality but these areas are believed to be of minor importance relative to the problem areas identified above. The general locations of water quality problem areas are shown on Figure 5 of Appendix C.

CHAPTER III

APPLICABILITY OF ABATEMENT METHODS

Definition of the major problem areas within the Lost Creek - Brown's Creek Watershed strongly suggests the abatement methods most applicable at specific localities. The suggested methods include both treatment and volume reduction techniques.

The treatment technique of abatement involves treating the discharge to improve water quality. On the other hand, volume reduction methods attempt to rectify the cause of poor water quality at its source. Volume reduction methods are often referred to as source control methods.

A number of possible abatement methods were reviewed to evaluate those procedures deemed most applicable to the major problem areas identified. Discussion of each is presented under the following headings:

VOLUME REDUCTION METHODS

Various volume reduction schemes reviewed included deep mine sealing, daylighting, solid waste disposal in conjunction with surface reclamation, and conventional surface reclamation methods.

Mine Sealing

Sealing of drift mine openings has been attempted in the Lost Creek - Brown's Creek region over a number of years. At best, the technique has had limited success. This is evident from field surveys made during this investigation, a review of FWPCA findings in 1965 and 1967, and study of the field experiments and survey work conducted by Halliburton. The Halliburton field experiments in sealing also involved the use of special grouting agents and methods.

The limited success achieved with mine sealing is due principally to complex conditions resulting from various mining operations. Deep mines are known to be interconnected and, in many areas, stripping and augering activities resulted in break-throughs into the deep mine workings. Numerous openings, many hidden or partially hidden, intersect the deep mine complexes. Within the Brown's Creek area alone, previous studies have identified a minimum of 80 mine openings.

Source 62062 represents one example of the type of mine seal failure which frequently occurs. Shortly after an adequate seal was constructed at the mine opening, the discharge reappeared at full force at a nearby location.

Mine sealing at present is not considered an applicable solution to the major pollution problems now existing in the Lost Creek - Brown's Creek area. Within this particular investigation, no additional consideration was given to the method.

Daylighting

Daylighting is the process which essentially removes the entire overburden over a deep mine complex, recovers the remaining coal and replaces the overburden, thus removing or burying the potential acid forming materials. Important factors in determining the feasibility of this method of reclamation are the amounts of overburden involved, the total value of the remaining coal to be recovered, the practicality of replacing the overburden without creating stability problems, and the alternate possibility of depositing the overburden in other areas to create usable land.

Areas in which daylighting would be a potentially feasible abatement technique were identified by field inspection. The Lost Creek area is geologically and topographically the most promising since several isolated hilltops which are ideally suited for daylighting are present. However, these candidate areas were found to contribute no acid mine drainage and thus were not considered further.

The possibility of performing a daylighting operation of major proportions was then investigated for the Brown's Creek area. An interconnected deep mine area of approximately 500 acres was defined which very likely is responsible for the majority of acid mine load carried by the SP-3A tributary.

Estimates developed in the analysis were as follows:

Area	500 Acres
Height of Overburden	50 - 250 Feet
Quantity of Overburden	124 Million CY
Unit Cost of Earthmoving	$0.30 Per CY
Total Cost of Earthmoving	$37.2 Million
Estimated Coal In-Place	30%
Recoverable Coal	1.3 Million Tons
Estimated Unit Value of Coal	$6.00 Per Ton
Total Value of Coal	$7.8 Million

The net cost of the work beyond the estimated value of recoverable coal is indicated to be almost $30 million. It would appear that such an investment could only be seriously considered if, in the process, a significant land area could be made useable and growth prospects in the area were highly promising.

With regard to growth prospects in the Brown's Creek area, the 1969 Comprehensive Development Plan for Harrison County projects little, if any, growth for the town of Mount Clare and surrounding Brown's Creek communities. The extreme narrowness of the valley is considered a primary deterrent.

It is possible that the daylighting of the 500 acres above SP-3A would produce about 1000 acres of useable land. Considering the daylighting costs previously developed, the cost of making this land useable would be on the order of $30,000 per acre. A per acre expendiutre of this magnitude to improve land for possible development does not seem realistic at this time. Considering both this cost and the poor growth prospects previously mentioned, it is concluded that daylighting at present is not a practical solution for the abatement of SP-3A pollution in the Brown's Creek area.

Other major problem areas in the watershed were reviewed for daylighting applications but these areas would appear to yield similar results. The underlying problem seems to be the very extensive areas and the large overburdens involved.

Strip Mine Restoration With Solid Waste Disposal

An evaluation of the possibility of combining a solid waste disposal program with strip mine restoration in the Lost Creek - Brown's Creek area was made.

The initial step in this analysis was to obtain information on present and future landfill requirements for the City of Clarksburg. Discussion with city officials indicated Clarksburg currently owns and uses for solid waste disposal a 100 acre site located within city limits. At anticipated disposal rates, use of the site by Clarksburg and most surrounding communities is projected for the next 35 years. The site was obtained approximately two years ago; prior to that time the city was in need of a suitable landfill site.

The Lost Creek - Brown's Creek Watershed was nevertheless searched for strip mine areas which might be useable for future solid waste disposal. A promising area from the standpoint of total area available, normal landfill slope requirements, absence of nearby dwellings, and accessibility is located on the west flank of Brown's Creek in strip mine 40074. This area, situated opposite the SP-2A tributary, consists of approximately 40 acres and might accommodate 15 to 20 years of disposal at present rates.

Strip area 40074 has been reclaimed. Thus, its use as a landfill site would not contribute greatly to the overall pollution reduction objective. Nevertheless, the site represents a potential future solid waste disposal area.

Conventional Surface Reclamation

Conventional surface reclamation techniques which were studied under volume reduction methods for this report included the removal or burial of gob and spoil material, grading to improve surface drainage, stream channel improvement or relocation, correction of subsidence areas to minimize water infiltration to deep mines, and providing vegetative covers where required. These methods were evaluated with reference to the following specific problem areas in the watershed.

SP-3A

The discussion of the Brown's Creek SP-3A problem area infers a need for surface restoration work along both branches of the tributary. Gob and spoil material are present and covering, regrading, and planting is required so that surface drainage into

the stream's branches does not add to the deep mine discharge problems. Some correction of the subsidence area is also required. The SP-3A areas requiring surface reclamation work are indicated on Figure 4 of Appendix C.

SP-4A

The SP-4A tributary requires surface reclamation work both at its origin and along its course toward Brown's Creek. At the stream's origin, some general clean-up and burial of spoil material and gob is necessary and a water impoundment is needed below drift mine entries 40064. The area is considered adaptable to construction of an impoundment which would aid in preventing the carrying of iron and other pollutants downstream.

Along its course toward Brown's Creek, the SP-4A tributary requires stream channel clean-up over a distance of approximately one mile. Where the SP-4A stream parallels the refuse covered access road, some clean-up and planting is necessary to prevent future erosion and contamination of the stream. Improvement of the access road with the placement of limestone chips along the shoulder would be beneficial in terms of up-grading road stability and providing some neutralizing effect upon runoff contaminated by the acid producing road materials. The length of roadway requiring improvement is approximately 1/2 mile. The general location of proposed surface reclamation work in the SP-4A area is shown on Figure 4 of Appendix C.

LC-4A

The LC-4A problem area in Lost Creek requires extensive surface restoration due to the large amounts of acid producing materials which are present. Clean-up, burial, regrading and planting operations are necessary over some 15 acres in the former coal preparation plant area and the region along Lost Creek just upstream of the mouth of the LC-4A tributary.

The LC-4A tributary is alkaline or near-alkaline upstream of the plant location and improvement of surface conditions should correct the bulk of the acid discharge. The location of required surface restoration work in the LC-4A area is shown on Figure 4 of Appendix C.

In addition to the areas discussed above, there are a number of small areas within the watershed in which reclamation or clean-up work can be justified on the basis of improving the area from an environmental viewpoint, if not on the basis of acid mine discharges. The bulk of this work would consist of clean-up, regrading and planting. Because of their isolated nature, each work area is not discussed individually but locations are indicated on Figure 5 of Appendix C.

A ten mile section of the new I-79 Interstate is now completed and open to traffic in the immediate area of the Lost Creek and Brown's Creek Watershed. The completed section runs from Fort Stonewood southwest to McWhorter. Along this course the roadway crosses the southern extremity of the Brown's Creek drainage area and essentially divides the Lost Creek Subwatershed in half. (See Figure 5, Appendix C).

The appearance of the land area adjacent to this section of I-79 is of interest. Strip mine areas visible or partially visible to the north of the Interstate have recently been reclaimed and seeded, but bond release has not yet been made since two growing seasons have not expired. This could occur in late 1973 or early 1974. Although the tops of the remnant highwalls can be seen from I-79, the area overall projects a reasonably good appearance; the valley contained between the two main strip areas is clean and picturesque and the strips themselves are located at an elevation considerably higher than that of the roadway.

To the south of the I-79 roadway, there is one active strip mine near the western boundary of the Lost Creek Subwatershed. The present appearance of this area from I-79 is poor but presumably will be corrected when stripping is complete. The stripper, United Coals, is planning what amounts to a small daylighting operation in the area. No additional strip mines are readily visible to the south of I-79.

TREATMENT METHODS

Because deep mine discharges are the primary sources of acid mine drainage at several locations in the Lost Creek - Brown's Creek Watershed and because volume reduction methods seem unrealistic in terms of providing an overall solution, treatment is considered a practical method for achieving abatement at these locations. The treatment techniques evaluated include the processes of lime neutralization, ion exchange and reverse osmosis. Discussion of each method follows; cost and benefit comparisons are provided in the subsequent section of the report.

Lime Neutralization

Conventional lime neutralization involves the use of alkali, normally hydrated lime or limestone, to neutralize acid mine drainage. The process has been the most widely used method of AMD treatment. The principal objective of the treatment is to remove acidity, iron and other metals which form insoluable oxides.

Treatment by lime neutralization is considered applicable to both the SP-3A problem tributary in the Brown's Creek area and Source 62062 which discharges directly into the West Fork River. Both sources exhibit high acidity and high iron concentrations.

Suitable locations for separate lime neutralization plants exist in the vicinity of SP-3A and Source 62062. Approximate locations are shown on Figure 5 of Appendix C. The Source 62062 location is particularly attractive because of its level terrain and because it is well removed from existing dwellings. The possibility of utilizing one lime treatment plant to treat Source 62062 and SP-3A has also been considered. The merits of using a single plant versus two individual plants are discussed later in this report.

Ion Exchange

The ion exchange process of treatment involves replacement of undesirable sulfate ions in AMD with hydroxide or bicarbonate ions. The exchange medium is normally a synthetic resin.

Ion exchange is applicable to the same problem areas considered for lime neutralization. Possible plant locations are as discussed under lime neutralization. Various comparisons of costs and benefits are reviewed in the next section of this report.

Reverse Osmosis

The reverse osmosis method of AMD treatment utilizes a semi-permeable membrane which permits water permeation but acts as a barrier to the passage of dissolved and suspended solids. The rejected materials form a concentrated acid brine while the product water can be of drinking quality.

As with lime neutralization and ion exchange, the reverse osmosis treatment method is applicable to the SP-3A and Source 62062 discharges. Possible plant locations are also as determined for the two previous treatment techniques.

CHAPTER IV

COSTS AND BENEFITS

GENERAL

Costs and benefits associated with possible solutions to the Lost Creek and Brown's Creek mine drainage problems are summarized in this section. The abatement techniques evaluated are those methods previously considered applicable to specific problem areas.

Plans involving a combination of abatement methods are developed to provide an overall solution for the watershed. Costs and benefits are also reviewed with respect to a least cost solution and to a best long term solution which gives consideration to improvement of environmental factors in addition to reduction of acid mine drainage.

In reviewing the discussion of the four major problem areas in the study area, it is apparent that the AMD in two areas, SP-4A and LC-4A, can be abated by volume reduction methods. In our opinion, the majority of acid mine drainage in the two remaining problem areas, SP-3A and Source 62062, can only realistically be handled by treatment methods.

COSTS AND BENEFITS - VOLUME REDUCTION METHODS

Based on previous discussion, the surface reclamation techniques required for correction of the SP-4A and LC-4A problem areas are reasonably well defined. A summary of estimated costs of correcting these two areas and the anticipated benefits to be derived from the expenditures follows:

SP-4A Brown's Creek Area

Problems:

Estimated AMD slugging potential is 200 lbs/day.

Source causes initial discoloration of Brown's Creek.

Cost of Correction:

Impoundment Construction	$ 35,000
Regrading and covering of spoil and gob pile areas (approximately 20 acres @ $2000 per acre)	40,000
Stream channel clean-up (1 Mile)	10,000
Road improvement and related clean-up	10,000
Miscellaneous clean-up and hauling	5,000
Estimated Total Cost for SP-4A Correction:	$100,000

Benefits:

The estimated reduction in the slugging potential is 75% or 150 lbs/day.

The correction should result in removal of a primary source of discoloration of Brown's Creek and significantly improved visual conditions in the SP-4A area.

LC-4A - Lost Creek Area

Problems:

Average acid loading of 1000 lbs/day caused by poor surface conditions.

Unsightly environment especially in the former coal plant area.

Abundance of scrap equipment and vehicles in area.

Cost of Correction:

Regrading, covering, planting in coal plant areas (approximately 15 acres @ $3000 per acre)	$ 45,000
Stream channel diversion and clean-up (700 ft.)	30,000
Create stream channel upstream of large spoil area	5,000
Miscellaneous clean-up and hauling (dismantle coal plant remains and remove 10-12 pieces of machinery or vehicles)	15,000
Estimated Total Cost for LC-4A Correction	$ 95,000

Benefits:

The estimated AMD reduction is 85% or 850 lbs/day.

Esthetic improvements in the LC-4A area.

In addition to the work required at SP-4A and LC-4A, there is some high priority surface reclamation necessary (in conjunction with installation of treatment facilities) at the SP-3A location in Brown's Creek. The estimated capital cost for this restoration is $30,000. This restoration principally involves regrading of spoil and gob areas, correction of some surface subsidence and related clean-up in the area. The AMD reduction attributable to the proposed surface reclamation work at SP-3A is estimated at approximately 100 lbs/day; esthetic improvements are the prime consideration.

Other more isolated areas in the watershed merit reclamation but are considered second priority because they do not directly contribute pollution loads to the presently defined major problem areas. Estimated reclamation costs for these areas (40 acres) is $80,000.

The general location of all areas requiring surface reclamation, both first and second priority, are shown on Figure 5 of Appendix C.

COST AND BENEFIT COMPARISONS OF TREATMENT METHODS

The alternatives available with respect to treatment methods and plant locations for SP-3A and Source 62062 are considered to be the following:

1. Lime Neutralization
2. Ion Exchange
3. Reverse Osmosis
4. Plant Locations: Individual plants in the vicinity of the specific problem areas or single plants serving both areas.

Cost estimates developed for lime neutralization, ion exchange, and reverse osmosis are summarized in detail on Table 1 of Appendix B. A comparison of the estimated cost data and anticipated benefits follows:

Lime Neutralization

Plant at SP-3A:	Capital Cost	$116,000
	Operating Cost/Yr.	15,000
Plant at Source 62062:	Capital Cost	$256,000
	Operating Cost/Yr.	35,000
Combined Plant for SP-3A and Source 62062 at Source 62062:	Capital Cost Plant	$315,000
	Capital Cost Lines	100,000
	Operating Cost/Yr.	50,000

Anticipated Benefits: Lime neutralization would be expected to reduce the SP-3A and Source 62062 acid and iron loadings by some 85%. Based on estimated current loads, these reductions would amount to approximately 1150 lbs/day at SP-3A and 2150 lbs/day at Source 62062.

Ion Exchange

Plant At SP-3A:	Capital Cost	$470,000
	Operating Cost/Yr.	140,000
Plant at Source 62062:	Capital Cost	$830,000
	Operating Cost/Yr.	239,000
Combined Plant for SP-3A and Source 62062 at Source 62062:	Capital Cost Plant	$950,000
	Capital Cost-Lines	100,000
	Operating Cost/Yr.	281,000

Anticipated Benefits: Ion exchange treatment of the SP-3A and Source 62062 discharges would be expected to eliminate almost 90% of the acid and iron loadings present. The load reductions are estimated to be 1300 lbs/day at SP-3A and 2300 lbs/day at Source 62062.

Reverse Osmosis:

Plant at SP-3A	Capital Cost	$ 320,000
	Operating Cost/Yr.	84,000
Plant at Source 62062:	Capital Cost	$ 570,000
	Operating Cost/Yr.	1442,000
Combined Plant for SP-3A and Source 62062 at Source 62062:	Capital Cost-Plant	$ 650,000
	Capital Cost-Lines	100,000
	Operating Cost/Yr.	171,000

Anticipated Benefits: The reduction of acid and iron loadings by reverse osmosis is expected to be near 95% of the existing loads at the above sites. This reduction would be on the order of 1400 lbs/day at SP-3A and 2400 lbs/day at Source 62062.

TREATMENT METHODS - PROS AND CONS

Major advantages and disadvantages which may be cited for the three treatment methods, including cost considerations, are summarized as follows:

Lime Neutralization

Advantages :

1. Capital and operating costs signficantly lower than alternative methods.
2. Proven method of treatment; not research oriented.

3. Operating man-power requirements not restrictive.

4. Two small plants may be operated by the same personnel.

Disadvantages:

1. Sulfate loads are essentially unaffected and net hardness may be added to the effluent.

2. Method corrects AMD problem but is restricted in terms of improving other environmental problems.

Ion Exchange

Advantages:

1. Effluent quality better than lime neutralization.

2. Method possibly adaptable to correction of other environmental problems.

3. Provides research demonstration opportunity.

Disadvantages:

1. Capital and operating costs not clearly defined but seemingly very high.

2. Highly skilled operators required.

3. Effluent quality more unpredictable than other methods.

4. Process has not been totally proven with respect to large scale treatment of AMD.

5. Severe disposal problem for waste regenerant.

6. Resin life is shortened by iron fouling.

Reverse Osmosis

Advantages:

1. Effluent quality better than lime neutralization.

2. Probably less costly than ion exchange.

3. Process is adaptable to improvement of other environmental problems; i.e., product may be used as potable water supply and concentrated brine product may be used advantageously in sewage treatment.

4. Provides research demonstration opportunity.

Disadvantages:

1. More costly than lime neutralization.

2. Requires highly skilled operating personnel.

3. Generally not feasible unless end use for product water exists.

4. Success not totally confirmed by large scale treatment of AMD.

5. Brine disposal normally a problem.

REVERSE OSMOSIS RELATED POSSIBILITY

Reverse osmosis treatment offers an interesting possibility in terms of improving one additional environmental problem in the Lost Creek - Brown's Creek area. This possibility is introduced and developed within the following items:

1. The Harrison County Comprehensive Development Plan (1970) reports that the community of Lost Creek may experience a great deal of growth within the next 10 to 15 year period. A possible population of 1500 is projected for 1985, approximately double the current level. The primary reason for expected growth is the relatively flat land which occurs within the valley and the presence of the new I-79 Interstate Route which passes through the town.

2. A number of dwellings in the Lost Creek community currently discharge wastes directly into Lost Creek or its tributaries. This situation is unhealthy and, as suggested in the Comprehensive County-Wide Water and Sewer Systems Planning Report (1968), should be corrected with the installation of sewage treatment facilities. This particular problem will become more acute as Lost Creek growth becomes a reality. Conversely, sewage treatment facilities could well enhance growth prospects.

3. Public water supply for the various communities of the Brown's Creek and Lost Creek areas is currently supplied by the Clarksburg Water Plant through the Lost Creek - Mount Clare Public Service District Water System. The water is purchased by the P. S. D. by meter at the Country Club Road beyond the mouth of Brown's Creek. The possibility exists that the Brown's Creek - Lost Creek area could develop its own source of public water supply and thus discontinue its purchase of water from Clarksburg. Preliminary discussions with officials of the Clarksburg Water Board indicate the plan is feasible from the viewpoint of effect on their current operations.

4. The product water from a reverse osmosis plant located near the SP-3A problem area in Brown's Creek could meet the current needs for the public water supply for the Lost Creek - Brown's Creek area. Although more detailed stream flow data would be required, preliminary information suggests the flow rate of SP-3A (average of 150 gpm based on the Halliburton data) is appropriate to meet water supply requirements for a population of 1500.

5. Reverse osmosis normally results in a disposal problem for the produced concentrated brine. Recent studies have indicated that this brine, when neutralized and used in proper proportions, can be used beneficially in sewage treatment operations. The neutralized brine has been shown to enhance primary settling, improve sludge conditioning and remove virtually 100% of phosphates, while not inhibiting activated sludge. The proportion of neutralized brine which can be effectively disposed of through a sewage plant is normally one part brine per nine parts sewage. The capacity of a Lost Creek sewage facility, based on projected population estimates, would be on the order of 150,000 gal/day. The amount of neutralized brine which could be disposed of through a plant of this capacity would be approximately 15,000 gal/day. Thus, the reverse osmosis plant at SP-3A could possibly be designed so that acid brine production balances acid brine requirement at the sewage plant.

6. Excess neutralized brine sludge from the reverse osmosis plant, if any, could be disposed of by depositing in abandoned deep mines in the immediate Brown's Creek area.

7. A reverse osmosis plant in the Brown's Creek area would provide demonstration possibilities as a follow-up to work performed at Norton, West Virginia and Mocanaqua, Pennsylvania.

SOLUTIONS - LEAST COST VERSUS LONG TERM

The primary objectives of this investigation were (1) to provide a recommendation for a least-cost solution to the mine drainage problem in the Lost Creek and Brown's Creek Watershed and (2) to present a recommendation as to the best overall solution to the AMD problem with consideration given to associated long range benefits to the Lost Creek - Brown's Creek areas.

On the basis of the defined major pollution problems in the study area and preliminary cost and benefit estimates, two abatement plans have been developed. One plan presents what may be considered a least-cost plan; the second plan offers a long-term solution.

Least Cost Plan

The least-cost plan consists of the following:

Area	Abatement Method	Estimated Capital Cost
SP-3A	Lime Neutralization Plant	$116,000
SP-3A	Associated Surface Reclamation	30,000
66062	Lime Neutralization Plant	256,000
SP-4A	Surface Reclamation	100,000
LC-4A	Surface Reclamation	95,000
-----	Contingency (15%)	83,000
Estimated Least-Cost Solution Total:		$680,000

The collective benefits associated with the above least-cost plan include an estimated reduction in acid and iron loads of 4400 lbs/day, clean-up of unsightly areas now present in the vicinity of the major sources, and general improvement in the appearance of Brown's Creek and Lost Creek.

In addition to the estimated capital outlay of $680,000 required for least-cost solution, an annual operating cost estimated at about $50,000 is anticipated. Details on the development of this operating cost estimate are provided in Table 1 of Appendix B. The $50,000 estimate assumes that both lime neutralization plants can be operated by the same personnel. This assumption is believed to be realistic in view of the

combined plant capacities of only about 0.85 MGD. As cost data in a previous section of this report indicates, the prime factor which tends to make a single plant (treating two AMD sources) unattractive is the additional capital cost of $100,000 for collection facilities.

Recommended plant locations and proposed surface restoration areas for the least-cost plan are shown on Figure 5 of Appendix C.

Long Term Solution

The plan suggested as a best long-term solution, considering total environmental impact on the region, is outlined as follows:

Area	Abatement Method	Estimated Capital Cost
SP-3A	Reverse Osmosis Plant	$320,000
-----	Water Storage Tank	150,000
-----	Additions to Distribution System	50,000
SP-3A	Associated Surface Reclamation	30,000
62062	Lime Neutralization Plant	256,000
SP-4A	Surface Reclamation	100,000
LC-4A	Surface Reclamation	95,000
-----	Sewage Treatment Plant	273,000
-----	Collection System	217,000
-----	Brine Transport Lime	53,000
Various	2nd Priority Surface Reclamation	80,000
-----	Contingency (10%)	160,000
Estimated Long-Term Solution Total:		$1,784,000

The benefits associated with the total long-term plan include an estimated reduction in pollution load of 4700 lbs/day, clean-up of the more unsightly surface areas in the watershed, provision of a needed sewage treatment plant in the Lost Creek area, the establishment of a small-scale reverse osmosis plant useful for experimentation as

well as water supply and a demonstration of a method of disposal of concentrated brine product from a reverse osmosis plant.

Under the long term solution, capital cost for a one million gallon water storage tank is included with the reverse osmosis costs. If some arrangement for emergency water supply from Clarksburg could be made, this cost could possibly be avoided. A storage tank of only 153,000 gallons currently exists within the Brown's Creek area.

Lime neutralization at Source 62062 is proposed in the long-term plan as well as the least-cost solution. Treatment of this source by reverse osmosis does not appear feasible in terms of additionally required capital and resultant high volumes of product water and brine.

The long term solution includes surface restoration at several locations in the watershed which are not included within the least-cost plan. These locations are second priority reclamation areas which merit work principally on the basis of esthetic considerations.

Details on estimated capital costs for the sewage treatment plant and collection systems are presented on Table 2 in Appendix B.

As might be anticipated, significant operating costs are associated with the long-term plan. However, a direct comparison of the operating costs with those of the least cost plan is not realistic since the long-term solution aims at correcting a number of environmental problems not considered in the least cost plan. Long-term operating costs, details of which are provided in Table 1 and 2 in Appendix B, are summarized as follows:

SP-3A Reverse Osmosis Plant and Related Facilities	$ 84,000
Lime Neutralization Plant At Source 62062	35,000
Sewage Treatment Plant	27,000
Sewage Collection Systems	15,000
Brine Transport Pipeline	9,000
Total Estimated Annual Operating Cost:	$170,000

The anticipated operating cost for the reverse osmosis plant is particularly high and is strongly influenced by plant size. As indicated on Table 1 of Appendix B, the operating cost has been calculated at $1.06 per 1000 gallons of product water. With the rapidly advancing technology on reverse osmosis systems, it is conceivable that an operating cost significantly lower than that now estimated could be achieved prior to an actual plant construction.

Suggested plant locations and surface restoration areas are shown on Figure 5 of Appendix C.

POSSIBLE SOURCES OF FUNDS

Possible major sources of funds for supporting the construction and subsequent operation of abatement facilities in the Lost Creek - Brown's Creek area include the following:

1. West Virginia Department of Natural Resources
2. Environmental Protection Agency
3. Appalachian Regional Commission
4. Public Service Consumers
5. Former Mine Operators

Preliminary discussions with officials of the West Virginia Department of Natural Resources indicate that funds could be made available for surface reclamation work in the watershed. The monies would be supplied through the general reclamation fund in the Division of Reclamation. The ease of obtaining these funds would depend on the Department's evaluation of the priority of the reclamation work with consideration given to factors such as impact on water quality improvement, downstream effect of the restoration, and other environmental and esthetic considerations. It is believed that a strong case could be made for funds on the basis of water quality improvement and the relationship of the work to the upgrading of environmental conditions in the region. Within specific reclamation areas, (where final land releases have not yet been made) it may be possible for the Department of Natural Resources to further scrutinize the proposed or completed reclamation for compliance with current regulations, and in so doing, possibly cover some of the costs of reclamation. An additional source of funds might be former mine operators to whom legal responsibility might be assigned. This subject is covered in more detail in a subsequent section of this report.

The amendments of 1972 to the Federal Water Pollution Control Act (Section 107) provide a means whereby federal funds could be made available for the construction of various plants considered for the Lost Creek - Brown's Creek area. Under Section 107, the Environmental Protection Agency, in cooperation with the Appalachian Regional Commission, is authorized to make expenditures for projects which demonstrate engineering and economic feasibility of abatement techniques which contribute toward elimination or control of mine water pollution. The amendment also makes allowances for funds to demonstrate methods which utilize sewage sludge materials or other municipal wastes to diminish or prevent other pollution affecting

water quality. Certain expenditures, particularly the reverse osmosis facilities proposed in the long-term solution for the watershed would seem justifiable within this context of Section 107.

A portion of the funds necessary for the operation of a reverse osmosis plant and a sewage treatment plant could be ultimately obtained from consumers, as is normally the case where water supply and sewage services are supplied to communities. The extent to which the generally low-income residents of the watershed area would be willing (or able) to support these particular services presents some serious socio-economic questions. At this stage it seems reasonable to conclude that consumers could pay a share but that the uniqueness or experimental nature of the facilities would justify grants or subsidies of some form from federal, state and possibly local government agencies.

To obtain funds for construction and operation of possible lime neutralization plant(s), a program could be developed which would provide for the sharing of costs between such agencies as the Environmental Protection Agency, the Appalachian Regional Commission, and the West Virginia Department of Natural Resources. The segment of funding seemingly most adaptable to the state agency would be those portions concerned with annual operation after completion of construction. Preliminary discussions with officials of the West Virginia Department of Natural Resources indicate there are no funds available for the operation of these plants and that there seem to be no provisions for making such funds available. It would appear that all possibilities of making whatever provisions are necessary to obtain funds would warrant examination.

CHAPTER V

OTHER CONSIDERATIONS

Within the scope of this investigation, certain additional problems were to be evaluated with respect to the overall pollution reduction objective. These other considerations were to include:

1. A survey of public reaction to the hardness in the public water supply in the Clarksburg area.
2. An evaluation of installing pre-treatment facilities at the Clarksburg Water Plant.
3. A determination of the effect of current strip mining on Brown's Creek water quality.
4. An investigation of the non-public responsibility for mining area restoration.

Each of these items are discussed in accordance with the information gathered under the following headings.

PUBLIC REACTION TO HARDNESS

Hardness in the raw water supply of the Clarksburg Water Plant has been a problem since the early 1940's. The problem is directly associated with the level of mining activity within the drainage areas contributing to the water supply. The hardness is attributable to chemical processes at the time of mine acid formation and to neutralization which subsequently occurs as a result of contact of the acid mine drainage with soluable rock minerals.

A historical plot of the average hardness of the raw water intake at the Clarksburg Water Plant is provided in Figure 2. Water hardness increased steadily beginning in the 1940's and appeared to peak in 1965 when a severe drought occurred in the region. At that time, officials of the Clarksburg Water Board were deeply concerned that standards set by the United States Public Health Service could not be met.

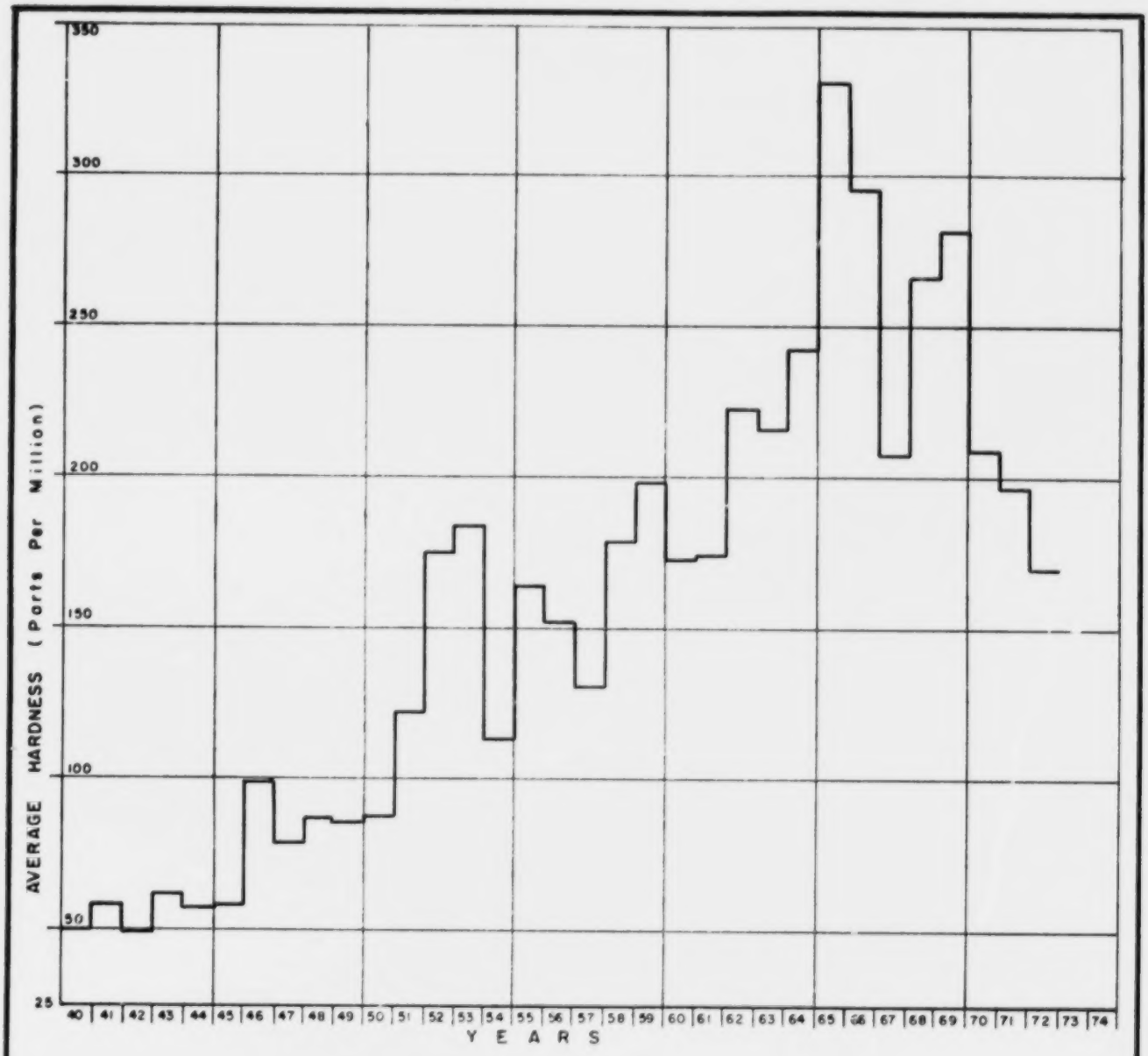

Figure 2

WATER HARDNESS AT CLARKSBURG WATER PLANT

NOTES 1. Average Taken For 6 Month Period For The Year 1972

2. All Basic Data Provided By Clarksburg Water Board.

DATE:	LOST CREEK & BROWNS CREEK WATERSHED Harrison County West Virginia	AVERAGE HARDNESS RAW WATER INTAKE CLARKSBURG WATER
SCALE:		
DR: CK:	A. C. ACKENHEIL & ASSOCIATES, INC. CONSULTING ENGINEERS PITTSBURGH, PA., CHARLESTON, W. VA. & BALTIMORE, MD.	
DWG. NO.		

PR 1124-771

Since 1965 the average hardness of the plant raw water intake has declined and has remained at approximately 170 ppm over the past year. According to operating personnel of the Clarksburg Water Plant, this hardness level does not seriously affect present operations. Treatment for water hardness is not performed at the plant.

An attempt was made to estimate the net contribution of the Brown's Creek - Lost Creek Watershed to the total hardness problem at Clarksburg. Based on direct correlation to drainage area, Brown's Creek and Lost Creek would be expected to provide 7% of the water supply intake at the Clarksburg Plant. Applying a weighting technique to this estimate to account for differing levels of hardness of various streams (See Table 4, Appendix A) it is likely that Lost Creek and Brown's Creek is accountable for something between 10% and 15% of the total hardness problem at the Clarksburg Water Plant. This estimate is significant in relation to the relatively small drainage areas which Lost Creek and Brown's Creek represent, but not too meaningful in terms of the total hardness problem which exists at the Clarksburg Plant. The conclusion to be developed here is that the net effect on hardness at the Clarksburg Water Plant will most probably be minimal as a result of work in the Lost Creek and Brown's Creek Watershed.

A number of Clarksburg area residents were randomly selected and questioned with respect to attitudes on water hardness. Specific questions asked were the following:

1. Do you consider the hardness of Clarksburg water a problem?
2. Would you favor softer water?
3. Do you own a water softener and do you currently use it?
4. Would you be willing to pay for softer water?

The usual responses received generally indicated unconcern or satisfaction with the current situation and a general reluctance to pay for improvement. A number of factors seem to have influenced the general reactions. These factors are:

1. Severe water hardness has not existed in the area since 1965. With the passing of time, the residents have undoubtably minimized the significance of the problem.

2. Residents of the Clarksburg area have seemingly learned to to live with the hardness problem especially since the situation has become less severe over recent years. A number of residents in past years purchased home water-softening units. But possibly more than 50% of these units are now no longer in service.

3. The Clarksburg area residents currently enjoy relatively low water rates and generally do not react receptively to the idea of softer water at additional cost. The amount of additional cost would be a factor; however, the public generally exhibits wariness at the mention of softer water at higher cost.

POSSIBILITY OF PRE-TREATMENT FACILITIES AT CLARKSBURG

Within this investigation, a preliminary evaluation of the feasibility of installing pre-treatment facilities at the Clarksburg Water Plant was to be made.

Water softening facilities are required at the Clarksburg Plant. The need for these facilities may be considered a direct result of AMD problems in those watersheds which feed the West Fork River, including the Lost Creek and Brown's Creek Watershed.

The desirability of treating for water hardness at the Clarksburg Water Plant brings forth a more serious problem which exists at the plant. There are at present no facilities at the plant for the proper handling

and disposal of sludge. The ultimate need for sludge treatment facilities exists, with or without softening, in order to maintain water quality in the West Fork River. At present, sludge volumes (accumulating at an approximate rate of 2500 gal/day) are periodically dumped into the West Fork River. This dumping normally occurs every three months when sedimentation basins are drained and manually cleaned. Although sludge volumes which are dumped are relatively small, the operation is not in the best interests of preserving water quality and facilities for proper handling of sludge will ultimately be required.

To provide for proper sludge disposal and water softening at the existing plant, additional land and major facilities would be required. The facilities include a sludge thickener, a dewatering unit, and a recarbonation unit-assuming a lime soda softening process is used. Capital costs are estimated as follows:

Land	$ 50,000
Thickener	75,000
Vacuum Filter	75,000
Recarbonation Unit	25,000
Plant Revisions, Etc.	40,000
Total:	$265,000

Operating costs which would be incurred as a result of the addition of the above facilities would include chemical costs, incremental power, labor and maintenance costs, and ultimate disposal costs for dewatered sludge. These costs are estimated to be some $30,000 annually.

Some portions of the Clarksburg Water Plant are now almost 100 years old. Considering the age and condition of some facilities, and the significant capital expenditure which would be necessary to incorporate

desirable modifications, it would seem logical that some serious consideration be given to the feasibility of constructing an entirely new plant. The firm of Gannett-Fleming-Corddry and Carpenter is presently performing a detailed study of the existing plant for the Clarksburg Water Board. The study is to evaluate such factors as raw water storage, hardness, possible plant revisions, as well as the feasibility of a new plant. The findings of the Gannett-Fleming-Corddry and Carpenter study should have a strong bearing on any decisions to be made relative to pre-treatment facilities at the Clarksburg Plant.

Some temporary and less costly provisions could be made at the existing plant to alleviate the current water hardness problem but these temporary modifications would result in decreasing total plant capacity from 10-12 MGD to a capacity nearer the plant's average output of 5-6 MGD. A description of the process and modifications necessary is as follows:

1. Convert approximately one-half of the plant's 15 sand filters to ion exchange beds. Present filtering capacity is 10-15 MGD.

2. Soften by ion-exchange treatment about 3 MGD or one-half of the plant intake. The treatment would reduce the hardness of this volume from about 170 ppm to zero. The remaining 3 MGD of plant intake would be treated by current filtration methods.

3. Blend the softened water with the unsoftened but filtered water. The resultant product water would have a hardness of about 80-90 ppm which falls within the normally recommended range of hardness for a potable water supply.

4. Regeneration of the ion exchange beds would involve the use of an existing (but presently unused) storage tank at the plant. This tank would be adaptable for mixing and storing brine solution necessary for back-washing the ion exchange beds.

The capital expenditures for initiating the described process is estimated to be $40,000. The majority of this outlay would involve the purchase of ion exchange resin. Some of the necessary piping for back-washing and blending presently exist at the plant; however, it is likely that some additional modifications would be required. Operating costs on the order of $40,000 annually could be anticipated for the described softening process.

The temporary modifications discussed above would not provide for proper handling of current sludge volumes. Conversely, incorporating the indicated changes would result in an added disposal problem. This added problem would involve the disposal of an estimated 7400 gal/day of waste regenerant.

Perhaps the most serious limitation which would be imposed on the Clarksburg Plant by the installation of temporary facilities would be the approximate 50% reduction in supply capacity of the plant. Although current average needs could be met, there would be little room to meet unexpected peak demands or to initiate supply to new customers.

EFFECT OF CURRENT STRIPPING ON WATER QUALITY

There is at present only one active strip mine within the Lost Creek and Brown's Creek Watershed area. This strip mine is located near the western boundary of the watershed just south of Interstate I-79. (See

Figure 5 in Appendix C). The present plan of the operator, United Coals, is to daylight a small area of approximately 8 to 10 acres.

Two northeast flowing tributaries of Lost Creek drain the general area which contains the United Coal active strip. Based on samples obtained and tested in August of 1972, these tributaries show no water quality deterioration. The northernmost tributary (Station LC-9 in Table 5, Appendix A) showed a net alkalinity, pH of 7.7, iron content of 0.1 mg/l, and sulfate concentration of 70 mg/l. The second tributary (Station LC-11 in Table 5, Appendix A) showed a net alkalinity, pH of 6.5, iron content of 0.1 mg/l, and sulfate of 125 mg/l. These samplings were made at the mouths of the streams prior to their entry into Lost Creek. Other pH measurements made on samplings closer to the mining area also indicate acceptable water quality.

Some recent strip mining was terminated in the Brown's Creek area in the spring of 1972. This stripping was performed by the Bell Mining Company, a small operator, under Permit 156-71. The work area is located to the east of Brown's Creek at the head waters of the SP-1A tributary. A total drainage area of 270 acres was to be affected by the stripping operation; however, only some 20 acres were stripped according to area inspectors. Operations were apparently stopped because of a marketability problem; area inspectors are doubtful that additional stripping will be performed within the forseeable future. Although actual mining is not taking place, the area is classified as active by the Department of Natural Resources since final reclamation and bond release has not been made.

The water quality of SP-1A does not appear to be affected by the former Bell Mining Company operations. As indicated on Table 2 of Appendix A, the SP-1A stream in August of this year showed net alkalinity, a pH of 6.4, and iron content of less than 3 mg/l.

Although only one strip mine is currently active within the Lost Creek and Brown's Creek Watershed, there are several additional strips which remain classified as active by the Department of Natural Resources simply because bonds have not been released. These other areas have been reclaimed to the point of final grading and seeding but a time period covering at least two growing seasons must elapse before final bond release will be made and the area removed from the active classification. Several large stripping areas which have recently been reclaimed are located just north of the I-79 Interstate in the Lost Creek area (See Figure 5, Appendix C). These strips were mined and reclaimed by Lecco, Inc. and are now awaiting growth of vegetative cover before bond release.

The water quality control measures currently used by area inspectors, as per West Virginia surface mining regulations, include a pH of 5.5 to 9.0, iron content of 10 mg/l or less, and turbidity of 1000 Jackson units (J. U.) or less four hours after a major rainfall of 1/2 inch in 30 minutes and not more than 200 J. U. after 24 hours. Daily monitoring by the operator is required and written records are to be maintained. A monthly compilation of the data is forwarded to the Reclamation Division of the Department of Natural Resources. On-site visitations by area inspectors are scheduled bi-monthly.

SURVEY OF NON-PUBLIC RESPONSIBILITY

An attempt was made in this investigation to identify restoration areas not rightfully public responsibility.

The initial work in this area consisted of reviewing mining regulations and significant changes in the regulations in the State of West Virginia over the past years. The next phase of work consisted of determining the dates at which significant mining operations were performed in the Lost Creek and Brown's Creek area and the applicable regulations in existence at the time of mining. The final work entailed an examination of specific mining areas and the development of opinions as to whether the mining was performed in accordance with existing regulations.

Deep Mining Considerations

A major share of the significant acid mine drainage problems in the Lost Creek and Brown's Creek Watershed is the result of former deep mining operations. This is the case in the SP-3A area, the Source 62062 area and, for the most part, the SP-4A area. In the LC-4A area, the primary drainage problem is a result of poor ground surface conditions but these conditions are predominantly an outgrowth of past underground mining.

On the basis of discussions with various West Virginia officials and review of applicable West Virginia data and opinions contained in the U. S. Environmental Protection Agency's - "Legal Problems of Coal Mine Reclamation" (Grout No. 14010 FZU, March 1972) the following items summarize the State's laws and regulations pertaining to deep mining:

1. Sealing of Deep Mine Openings:

   a. No requirements on sealing of deep mine openings prior to July 1, 1968.

   b. After July 1, 1968, sealing or ventilation of abandoned mines is required. (West Virginia Code Ann. Sec. 22-2-6 (1970).

   c. The statute on sealing applies to mines in active operation at the time of the act and not to mines abandoned prior to that time.

   d. The current statute makes no provision for maintenance and protection of seals which may be constructed.

   e. The prime intention of the statute is the protection of individuals who could come in contact with the mine and not acid mine drainage abatement.

2. Acid Mine Discharges (Water Quality):

   a. Prior to 1969, it was unlawful in West Virginia without permit to, "allow sewage, industrial wastes, or other wastes, or the effluent therefrom, produced by or emanating from any establishment to flow into the waters of this State" Section 20-5A-5 (a)(1).

   b. This law when tested has generally proven ineffective. Problems have generally arisen in court proceedings in proving that acid mine drainage was an "industrial waste" and that a mine was an "establishment."

   c. A 1969 amendment now makes it unlawful for any person, without permit, to "open, reopen, operate or abandon any mine . . ., or dispose of any refuse or industrial wastes or other wastes from any such mine . . . ." Section 20-5A-5(a)(6).

   d. The current law clearly places responsibility on mine operators in active mining situations but does not deal effectively with the problem of "orphan" mines or otherwise severed and/or divided ownerships. Although some of the language appears broad enough to place responsibility on all persons no matter how passive their role, the courts for the most part have been reluctant to impose liability in these situations because of lack of clarification of responsibility.

Surface Mining Considerations

Although a majority of the defined acid mine drainage problems in the Lost Creek - Brown's Creek area are traceable to deep mining operations, there are some areas where surface mining has contributed to some extent to the problem.

Again, on the basis of discussions with responsible officials of the State of West Virginia and review of the U. S. Environmental Protection Agency's - "Legal Problems of Coal Mine Reclamation" (Grout No. 14010 FZU, March 1972) the following summary relative to strip mine regulation is presented:

1. West Virginia enacted its first law directed at halting strip mine abuses in 1939 with the requirement of a $150 per acre bond for reclamation.

2. Between the years 1945 and 1965, a number of revisions were made to the surface mining regulations. These involved the adoption of registration fees, broader definitions of strip mining, the exclusion and subsequent reinclusion of augering within the strip mine concept, establishment of a reclamation fund, definitions on backfill requirements and soil and land aspects, planting requirements, special treatment of quarries, and provisions calling for more detailed proposal maps.

3. In 1967, West Virginia adopted a totally new act on surface mining and reclamation and established the Department of Natural Resources as it now exists.

4. A March 13, 1971 amendment to the act broadened or redefined the 1967 requirements. Major provisions of the current law are:

   a. Permit, good for only one year, required for each job. Reclamation plan required to obtain permit.

   b. No permits issued where sediment and acid mine drainage cannot be prevented feasibly, where past violations were involved or to revoked permit holders unless bond was paid.

   c. Bond amounts of $600 - $1000 per acre with $10,000 minimum.

   d. Reclamation fee of $60 per acre which is assigned to a special reclamation fund administered by the Department of Natural Resources.

   e. Reclamation to be completed within one year of expiration of permit but regrading operations are to be kept reasonably current.

Dates of Significant Mining Operations

A search was made of mining records in an attempt to identify mining companies and dates of operations in the Lost Creek - Brown's Creek problem areas.

In the SP-3A area, the deep mine complexes believed to be the source of acid mine discharges include the Penn Alpha Mine, the West Fork Mine and a northern extension of the Byron Mine.

Based on the partial information which could be located, the Penn Alpha Mine has a complex history. The mine is reported to have first been in full operation in 1905 and operational during the period from 1937 to 1941. The mine was closed in 1950 at which time it was owned by the Penn Alpha Coal Company. Other reported owners of the mine included:

New York and New England Coal Corporation - No Dates

J. J. B. Colliery, Inc. - 1937

Alpha Coal Corporation - 1940

Brown's Creek Coal Company - 1940

James J. Ash Jr. Coal Company - 1941

Penn Alpha Coal Company - 1941

No additional information could be located with respect to the years 1905 to 1937 and 1941 to 1950. It is likely that the ownership of the mine during these periods was in the hands of the Penn Alpha Coal Company. No ownership or operating records could be found for the West Fork Mine.

The Byron Mine was operated by the Hutchinson Coal Company. The mine was known as the Byron Mine only for the years 1913 - 1914. Thereafter the mine was known as the Hutchinson Mine. No additional information was located regarding dates of operation or ownership; the mine was presumably closed in 1930. The Hutchinson Mine workings are perhaps the most extensive in the immediate Lost Creek - Brown's Creek area.

The SP-4A problem area is traceable to discharges from the same Hutchinson Mine which affects the SP-3A area. Data available on the Hutchinson Mine has been presented in the preceeding discussion of the SP-3A area.

Source 62062 also represents drainage from the Hutchinson Mine. In this case, the discharge occurs in the vicinity of the southwestern extremity of the mine workings.

Acid drainage problems in the LC-4A area are primarily a result of poor surface conditions left from deep mining operations and, to a lesser extent, subsequent strip mining activities.

Some confusion exists in the records regarding the deep mine nomenclature and operators in this area. Records show there existed both a Ryder Mine and an Arthur Mine but these mines in fact may have been one. As far back as 1913, there is record of a Ryder Mine. The mine name was changed a number of times after 1913 but is known to have been operated by the Clair Corporation in 1933. Final operation of the mine, by the same corporation, is listed as 1944. The Arthur Mine, operated by the Pardee and Curtain Lumber Company, closed in 1945. Previous reported "owners" include:

Wilber Fuel Company - No Dates

Garrett Coal Company - No Dates

Clair Coal Company - No Dates

Long Fuel and Vulcan Coal Company - No Dates

Arthur Ryder Coal Company - No Dates

The relationship of the Arthur Ryder Coal Company to either the Arthur Mine or the Ryder Mine is unclear.

Strip mining in the general LC-4A area has been performed by the Petitto Brothers, Inc. Permit numbers and dates could not be located for the specific area where surface conditions are poor, but based on data found for adjacent permits, it is likely that the stripping operations were performed between 1960 and 1962. In the adjacent areas where permit numbers have been identified, reclamation has been performed satisfactorily by the operator.

Conclusions On Responsibility

All deep mining in the Lost Creek and Brown's Creek area was apparently completed in the early 1950's and thus is subject to the pre-1969 deep mining laws. Although the pre-1969 law deals somewhat ineffectively with the problem of deep mine discharges, one must generally conclude, at least under strict interpretation, that the operators of the various mines were not in direct compliance with the law. The fact is that deep mine discharges were permitted but the existing law stated it to be unlawful to "permit sewage, industrial wastes, or other wastes . . . . , to flow into the waters of this State."

The possibility that actual legal assignments of responsibility can be made is highly questionable. Though it may not be difficult at this level to conclude that various operators of the mines in question were responsible, it is another matter to expect the courts to arrive at similar opinions and effectively impose legal responsibilities. As stated previously, the courts have been inconsistent in past interpretations of the statutes and have been reluctant to impose liability where severed or divided ownerships existed. The solvency of corporations which operated in past years is yet another problem.

On the basis of surface mining regulations in effect during the period when the Petitto Brothers, Inc. strip mined in the LC-4A area, it is believed that the operations were not in strict compliance with the law. In our opinion the degree of reclamation performed is not adequate. However, it must be remembered that a great majority of the surface disturbance in the area is a result of deep mining operations within the Ryder and Arthur Mines.

Based on the partial information which could be gathered within this investigation, it may be concluded that the degree of responsibility which might be attributed to specific operators in specific problem areas are as follows:

Area	Operator	Degree Of Responsibility
SP-3A	Penn Alpha Coal Company	Primary
	Hutchinson Coal Company	Primary
	Five Additional Companies As Previously Identified	Secondary
SP-4A	Hutchinson Coal Company	Primary
Source 62062	Hutchinson Coal Company	Primary
LC-4A	Clair Corporation	Primary
	Six Additional Deep Mining Companies As Previously Identified	Secondary
	Petitto Brothers, Inc.	Secondary

The above designations are necessarily arbitrary in view of the limited ownership information which could be located during this study. It is believed that more detailed investigations would be required to more fully evaluate the question of non-public responsibility. It is possible also that the indicated degrees of responsibility would be altered on the basis of additional information.

In conjunction with the development of data within this portion of this study, current property owners in the vicinity of the proposed work areas have been identified. These property owners are listed in Table 3 of Appendix B.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

In our opinion, the following conclusions may be presented on the basis of information collected or developed during this investigation.

1. The water quality of Brown's Creek has improved considerably between the period from 1968 to 1972. Data gathered during this investigation shows the stream to be alkaline over its entire length while earlier studies showed the stream to be alkaline only in its upper reaches. Average water quality parameters at the mouth of Brown's Creek as determined in this investigation are as follows:

Flow, gpm	1464
pH	6.4
Acidity, mg/l	35
Alkalinity, mg/l	49
Iron, mg/l	5.5
Sulfate, mg/l	325
Net Alkaline Load, lbs/day	316

2. The 1972 water quality data for Brown's Creek is more limited than detailed information gathered previously. However, the improvement indicated by the recent data is confirmed by the trend of monthly data gathered over a period of years by the Clarksburg Water Board.

3. Lost Creek is also alkaline over its entire length on the basis of water quality information gathered during this study. A summary of recent water quality parameters for Lost Creek (samplings at mouth) is as follows:

Flow, gpm	2800
pH	6.4
Acidity, mg/l	29
Alkalinity, mg/l	50
Iron, mg/l	0.2
Sulfate, mg/l	230
Net Alkaline Load, lbs/day	696

4. Detailed previous information for Lost Creek water quality is not available but substantial improvement in the quality of this stream is also suggested from review of monthly data gathered by the Clarksburg Water Board.

5. Surface reclamation work completed in recent years is believed to be a prime factor in the indicated improvement in water quality in the Lost Creek and Brown's Creek Watershed.

6. Although both Lost Creek and Brown's Creek now appear to be alkaline over their total lengths, study of the water quality profiles of these streams show several tributaries to be strongly polluted with acid mine drainage.

7. Three major problem areas have been identified with respect to the pollution of specific tributaries of Brown's Creek and Lost Creek. A fourth major problem area has been defined but this source discharges mine drainage directly into the West Fork River. The average net acid load associated with all four major problem areas is estimated to total 4800 lbs/day. A combined iron load of almost 600 lbs/day is also discharged from these sources.

8. Two of the major AMD problem areas are primarily a result of poor surface conditions remaining from previous mining operations. It is anticipated that abatement can be achieved by normal surface reclamation techniques. If reclaimed, the combined reduction in AMD is estimated at 1000 lbs/day or about 80% of the existing acid loadings from these two sources.

9. The two additional major sources of AMD are primarily a result of discharges from abandoned deep mine complexes. (One of these sources does require some related surface reclamation work). Abatement of these sources is considered best achieved through treatment. Depending to a large extent upon the method of treatment selected and design details, the combined reduction in AMD at these two sources could range between 3000 to 3400 lbs/day, or about 85% to 95% of the existing acid load from these two additional sources.

10. Volume reduction techniques other than conventional surface reclamation methods have been evaluated as possible means of abating AMD within the Watershed. At the present, these techniques do not appear to be applicable to existing conditions within the area of study.

11. Treatment methods evaluated with respect to abatement of specific pollution sources include lime neutralization, ion exchange, and reverse osmosis. Lime neutralization appears to be the most direct and least costly method of treatment. The reverse osmosis treatment possibility becomes attractive only if considered in an overall plan which would provide additional benefits or services to residents in the study area.

12. A least-cost plan for solution of the major mine drainage problems in the Watershed has been developed. This plan consists of performing surface reclamation work at two locations and installing small lime neutralization plants at two additional locations. Estimated total capital cost of the plan is $680,000. Anticipated benefits of the plan include a reduction in pollution load (acid and iron) of 4300 lbs/day, clean-up of unsightly areas near the major sources, and general improvement in the appearance of Lost Creek and Brown's Creek.

13. A best overall solution to the mine drainage problems in the Watershed has also been developed. This plan gives consideration to some long range environmental benefits in addition to correction of the AMD problem. The long-term plan includes:

    a. Surface reclamation work at two major problem areas.

    b. Surface reclamation at approximately ten additional locations considered second priority work areas. The reclamation is aimed more at improving the appearance of the areas rather than correcting AMD problems.

    c. A lime neutralization plant to treat an additional major AMD source.

    d. A small reverse osmosis plant to treat AMD from a major source in Brown's Creek and to provide a potable water supply to the Lost Creek - Brown's Creek area.

    e. A sewage treatment plant in Lost Creek to improve health conditions in the area and enhance growth prospects.

    f. Provisions for transporting brine product from the reverse osmosis facility to the sewage treatment plant. The brine, normally a waste product, can be used benefically within the sewage treatment process.

The estimated capital cost of the long-term plan is $1,784,000. Benefits in addition to those indicated above include an estimated reduction in pollution load (acid and iron) of 4900 lbs/day in the watershed.

14. Possible sources of capital funds for carrying out either of the abatement plans include federal, state, and local agencies, public consumers, and former mine operators where legal responsibility might be assigned. Annual operating expenditures for AMD treatment plants presents a special problem since no provisions are presently made for such funds within the West Virginia Department of Natural Resources.

15. Only minor improvement in the quality of raw water supply to the Clarksburg Water Plant can be expected as a result of proposed abatement work in the Lost Creek and Brown's Creek Watershed. This conclusion is based on estimates of net contributions of various drainage areas, including the study area, to the West Fork River upstream of the plant. The more significant changes which can be expected would be reductions of perhaps 10 to 15% in iron and manganese concentrations.

16. Lime neutralization treatment of major sources in the Lost Creek and Brown's Creek Watershed would likewise be expected to have little adverse effect on the hardness level at the Clarksburg Water Plant. The current hardness of raw water intake at the Clarksburg Water Plant is approximately 170 ppm.

17. Pre-treatment facilities are required at the Clarksburg Water Plant to provide a means of sludge handling and disposal. Also, water softening facilities are desirable to upgrade the quality of product

water. The estimated capital cost for providing both sludge disposal and water softening facilities at the existing Clarksburg plant is $265,000. The availability of land area to handle these facilities at the existing plant site must be confirmed.

18. The installation of pre-treatment facilities at the Clarksburg Plant cannot be considered an alternative to performing abatement work in the Lost Creek and Brown's Creek Watershed. The major problems in the study watershed consist of AMD in specific tributaries, a lack of sewage treatment facilities, and a need for esthetic improvements. These conditions would not be altered by modifications made at the Clarksburg Water Plant.

19. Active strip mining is occurring at only one location within the Lost Creek and Brown's Creek Watershed. No effects on water quality are evident as a result of this operation.

20. Based on a review of former mining laws and regulations and an appraisal of existing mine drainage problems in the watershed, it is our opinion that former mining operations were not performed in strict compliance with the laws. It is possible that legal responsibility might be assigned to former operators within specific problem areas. Operators identified or partially identified relative to specific problem areas are presented within the text of this report.

21. The actual assignment of legal responsibility to former mine operators will prove difficult. Old mining records upon which the assignment of responsibilities should be based are either incomplete or lost in total. In addition, previous court rulings in West Virginia indicate a general reluctance to impose liability in "orphan" mine situations or where past ownerships are divided.

RECOMMENDATIONS

The following recommendations are made on the basis of data obtained and conclusions developed during this investigation:

1. Pursue all possible avenues for obtaining funds or methods of financing for the various segments of abatement plans defined in this report.

2. Implement as soon as practical a program to perform applicable surface reclamation work within the Lost Creek and Brown's Creek Watershed. It is anticipated that a commitment of funds for this type of work will be least difficult to obtain.

3. Perform the proposed surface reclamation work in accordance with established priorities. First priority reclamation consists of the surface restoration described at major source areas SP-3A, SP-4A and LC-4A in the least-cost abatement plan. Second priority reclamation includes work at additional areas defined within the long-term abatement plan.

4. Take steps to obtain the information which will permit further evaluation of the alternatives available relative to treatment methods of pollution within the Watershed. These steps would include:

    a. Obtaining detailed flow information at locations SP-3A and Source 62062 on which to base plant sizes.

b. Assembling preliminary design data for a possible reverse osmosis plant to be located at SP-3A. Emphasis should be given to confirmation of the suggested operating costs for such a plant.

c. Discussing with concerned officials and authorities the feasibility and merits of reverse osmosis and sewage treatment plants in the Lost Creek and Brown's Creek areas. Among others, the concerned groups would likely include members of the Harrison County Planning Commission, the State of West Virginia Department of Health, the Lost Creek-Mount Clare Public Service District, the Clarksburg Water Board and the West Virginia Department of Natural Resources.

5. Await the completion of a now in-progress engineering study of the Clarksburg Water Plant facilities prior to arriving at final decisions with respect to possible plant modifications.

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West Virginia Department of Natural Resources

Clarksburg Water Board

West Virginia Reclamation Association

U. S. Environmental Protection Agency

Harrison County Planning Commission

U. S. Department of Agriculture

West Virginia Road Commission

Bituminious Coal Research

Halliburton Company

Clarksburg Waste Department

West Virginia Geological Survey

U. S. Corps of Engineers

APPENDIX A

TABLE 1
BROWN'S CREEK
HALLIBURTON WATER QUALITY DATA
TWELVE MONTH AVERAGES, 1968-1969

Station	Flow gpm	pH	Acidity mg/l	Acidity lbs/day	Alkalinity mg/l	Alkalinity lbs/day	Net Acid Load lbs/day	Aluminum mg/l	Sulfate mg/l	Iron mg/l
SP-1	1400	6.2	80	1344	23.0	386	958	4.0	864	8.9
SP-2	1084	5.7	93	1210	9.5	124	1086	4.8	844	11.3
SP-3	781	6.7	68	639	47.8	448	191	4.2	736	7.9
SP-4	452	5.0	142	770	7.4	40	730	8.5	577	3.9
SP-5	289	6.5	35	121	55.0	191	(70)	2.7	318	1.9

Parentheses Indicate Net Alkalinity

TABLE 2
BROWN'S CREEK
SUPPLEMENTARY WATER QUALITY DATA
ACKENHEIL AND ASSOCIATES GEO SYSTEMS, INC.

Date	Station	Flow gpm	pH	Concentrations, mg/l						Loads, lbs/day		
				Acid	Alkalinity	Aluminum	Sulfate	Iron	Manganese	Acid	Alkalinity	Net-Acid
7/14/72	SP-1	---	6.7	34	44	0.5	300	9.5	4.0	---	---	---
8/24/72	SP-1	1464	6.0	36	54	0.5	350	1.5	2.0	633	949	(316)
Average	SP-1	1464	6.4	35	49	0.5	325	5.5	3.0	633	949	(316)
8/11/72	SP-1A	20	6.4	30	72	6.5	300	2.9	3.5	7	17	(10)
7/14/72	SP-2	---	6.3	30	30	0.4	1050	2.8	3.5	---	---	---
8/24/72	SP-2	1321	6.2	46	48	0.6	320	1.0	2.0	729	761	(32)
Average	SP-2	1321	6.3	38	39	0.5	685	1.9	2.8	602	618	(16)
8/11/72	SP-2A	400	6.8	16	82	2.5	260	1.6	1.6	76	393	(317)
8/24/72	SP-2A	180	6.3	24	74	0.1	350	1.2	2.0	52	160	(108)
Average	SP-2A	290	6.6	20	78	1.3	305	1.4	1.8	70	271	(201)
7/14/72	SP-3	---	6.5	32	70	0.3	925	2.6	5.0	---	---	---
8/24/72	SP-3	832	5.9	10	50	0.4	360	2.5	3.0	100	499	(399)
Average	SP-3	832	6.2	21	60	0.4	643	2.6	4.0	210	599	(389)
8/11/72	SP-3A	320	2.5	500	0	14.0	1150	55.0	1.5	1920	0	1920
8/24/72	SP-3A	188	2.7	408	0	10.0	1200	12.0	2.5	920	0	920
Average	SP-3A	254	2.6	454	0	12.0	1175	34.0	2.0	1384	0	1384
7/14/72	SP-4	---	7.4	16	84	0.8	275	5.0	6.5	---	---	---
8/24/72	SP-4	770	6.4	28	130	0.1	350	1.8	2.0	259	1201	(942)
Average	SP-4	770	6.9	22	107	0.5	313	3.4	4.3	203	989	(786)

TABLE 2 Con't.
BROWN'S CREEK
SUPPLEMENTARY WATER QUALITY DATA
ACKENHEIL AND ASSOCIATES GEO SYSTEMS, INC.

Date	Station	Flow gpm	pH	Concentrations, mg/l						Loads, lbs/day		
				Acid	Alkalinity	Aluminum	Sulfate	Iron	Manganese	Acid	Alkalinity	Net-Acid
8/11/72	SP-4A	400	6.8	58	170	1.0	300	2.6	3.5	696	2040	(1344)
8/24/72	SP-4A	285	6.4	24	168	0.2	400	2.8	5.0	82	575	(493)
Average	SP-4A	343	6.6	41	169	0.6	350	2.7	4.3	169	696	(527)
8/11/72	SP-4B	40	4.5	62	0	0.2	250	3.0	1.5	29	0	29
8/24/72	SP-4B	60	4.7	42	2	0.6	310	0.2	3.5	30	1	30
Average	SP-4B	50	4.6	52	1	0.4	280	1.6	2.5	31	1	30
7/14/72	SP-5	---	7.0	8	86	0.2	200	0.2	1.0	---	---	---
8/24/72	SP-5	112	5.9	22	22	0.1	360	0.2	3.0	30	30	0
Average	SP-5	112	6.5	15	54	0.2	280	0.2	2.0	20	73	(53)

Parentheses Indicate Net Alkaline Load

TABLE 3
BROWN'S CREEK WATER QUALITY
COMPARISON OF 1968-1969 AND 1972 AVERAGE DATA

YEAR	PARAMETER	STATION SP-1	SP-2	SP-3	SP-4	SP-5
68-69	Flow	1400	1084	781	452	289
72	gpm	1464	1321	832	770	112
68-69	pH	6.2	5.7	6.7	5.0	6.5
72		6.4	6.3	6.2	6.9	6.5
68-69	Acid	80	93	68	142	35
72	mg/l	35	38	21	22	15
68-69	Alkalinity	23	10	48	7	55
72	mg/l	49	39	60	107	54
68-69	Iron	9	11	8	4	2
72	mg/l	6	2	3	4	2
68-69	Sulfate	864	844	736	577	318
72	mg/l	325*	685	643	313	280
68-69	Net Acid Load	958	1086	191	730	(70)
72	lbs/day	(316)	(16)	(389)	(786)	(53)

*DATA QUESTIONABLE

PARENTHESES INDICATE NET ALKALINE LOAD

TABLE 4
SUMMARY
CLARKSBURG WATER BOARD
WATER QUALITY DATA
FOR
WEST FORK RIVER AND TRIBUTARIES

(Averages of Reported Values For Period July, 1971 to August, 1972)

Sample No.	Sampling Point	pH	Iron mg/l	Manganese mg/l	Hardness mg/l	Alkalinity mg/l
1	Hartland Dam	7.2	0.5	0.2	170	43
2	Davisson Run	7.7	2.1	0.8	653	87
3	Brown's Creek	7.1	10.4	1.9	855	43
4	Above Two Lick Dam	7.3	0.5	0.1	164	42
5	Sycamore Creek	8.0	0.4	0.2	566	114
6	Branch of Sycamore (Kirby Hill)	7.7	0.5	0.6	729	77
7	Above Highland Dam	7.4	0.9	0.3	149	39
8	Lost Creek (Near River)	7.0	0.8	1.3	478	37
9	Lost Creek (Above Petito Tipple)	7.3	0.7	0.4	231	59
10	Above West Milford Dam	7.3	0.6	0.2	136	41
11	Buffalo Dam	7.9	0.1	0.1	348	79
12	Isaac Creek	7.8	0.4	0.1	311	79
13	Hackers Creek	7.6	0.3	0.2	219	61
14	Kinchelde Creek	7.6	0.4	0.2	219	65
15	Freeman Creek	7.6	0.3	0.1	171	56
16	Polk Creek	7.5	0.4	0.3	171	53
17	Stonecoal Creek At Weston	7.1	3.4	0.8	155	30
18	Stonecoal Creek (Above Keeley Tipple)	7.3	0.9	0.5	142	41
19	West Fork At Weston Dam	7.1	0.7	0.2	68	27
20	Skin Creek Above Brownsville	7.2	0.4	0.1	78	31
21	West Fork Above Brownsville	7.2	0.4	0.1	58	26
22	West Fork At Walkersville	7.2	0.2	0.0	38	26
23	West Fork Below Swaney Tipple	7.1	0.4	0.0	41	25
24	West Fork At Ireland	7.2	0.3	0.0	37	26

TABLE 5
LOST CREEK
SUPPLEMENTARY WATER QUALITY DATA
ACKENHEIL AND ASSOCIATES GEO SYSTEMS, INC.

Date	Station	Flow gpm	pH	Concentrations, mg/l						Loads, lbs/day		
				Acid	Alkalinity	Aluminum	Sulfate	Iron	Manganese	Acid	Alkalinity	Net-Acid
7/20/72	LC-1	2500	5.8	38	52	0.0	250	0.1	0.5	1140	1560	(420)
8/11/72	LC-1	3100	6.7	20	48	0.2	210	0.3	1.0	744	1785	(1041)
8/30/72	LC-1	613	6.8	30	66*	0.8	180*	0.2	1.5	220*	485*	(265)*
Average	LC-1	2800	6.4	29	50	0.1	230	0.2	1.0	984	1680	(696)
7/20/72	LC-2	2400	5.8	12	44	0.0	230	0.2	0.7	346	1270	(824)
8/11/72	LC-2	2956	6.4	8	44	0.1	210	0.4	1.4	283	1560	(1297)
8/30/72	LC-2	348*	6.2	30*	34*	0.0	650*	0.1*	2.0*	125*	142*	(18)*
Average	LC-2	2678	6.1	10	44	0.0	220	0.3	1.1	321	1414	(1093)
8/11/72	LC-2A	60	6.5	18	58	1.1	270	0.1	1.9	13	42	(29)
7/20/72	LC-3	493	6.9	20	28	0.1	260	0.1	0.7	118	166	(48)
8/11/72	LC-3	515	6.6	30	46	0.2	230	0.2	1.2	185	284	(99)
Average	LC-3	504	6.8	25	37	0.2	245	0.2	1.0	151	224	(73)
7/20/72	LC-4	1950	5.8	30	30	0.0	250	1.4	0.8	700	700	0
8/11/72	LC-4	2477	6.5	36	42	0.0	190	0.7	1.2	1070	1248	(178)
8/30/72	LC-4	73*	3.5*	68*	0*	1.5*	1025*	42.5*	3.0*	59*	0*	59*
Average	LC-4	2214	6.2	33	36	0.0	220	1.0	1.0	877	956	(79)
7/20/72	LC-4A	363	3.7	252	0	3.0	1150	37.5	2.5	1100	0	1100
8/11/72	LC-4A	470	2.6	256	0	6.0	1325	13.3	3.5	1443	0	1443
8/24/72	LC-4A	180	2.8	246	0	2.8	900	3.0	10.0	531	0	531
Average	LC-4A	338	3.0	251	0	3.9	1125	17.9	5.3	1018	0	1018

TABLE 5 Cont'd.
LOST CREEK
SUPPLEMENTARY WATER QUALITY DATA
ACKENHEIL AND ASSOCIATES GEO SYSTEMS, INC.

Date	Station	Flow gpm	pH	Concentrations, mg/l						Loads, lbs/day		
				Acid	Alkalinity	Aluminum	Sulfate	Iron	Manganese	Acid	Alkalinity	Net-Acid
7/20/72	LC-5	454	6.3	22	54	0.1	300	0.2	0.5	120	304	(184)
8/11/72	LC-5	365	6.0	46	64	0.0	240	0.1	0.6	201	280	(79)
Average	LC-5	410	6.2	34	59	0.0	270	0.2	0.6	167	290	(123)
7/20/72	LC-6	71	5.5	16	18	0.0	300	0.4	0.9	14	15	(1)
8/11/72	LC-6	46	5.8	24	14	0.4	230	0.1	1.9	13	8	5
Average	LC-6	59	5.7	20	16	0.2	265	0.3	1.4	14	11	3
7/20/72	LC-7	300	6.1	16	114	0.0	150	0.3	0.0	58	410	(352)
8/11/72	LC-7	450	6.3	16	94	0.2	130	0.1	0.2	86	508	(421)
Average	LC-7	375	6.2	16	104	0.1	140	0.2	0.1	72	468	396
7/20/72	LC-8	750	6.4	26	60	0.0	44	0.2	0.0	234	540	(306)
8/11/72	LC-8	1300	6.4	20	50	0.4	70	0.2	0.2	312	780	(468)
8/30/72	LC-8	63*	5.9*	12*	70*	0.6	130*	0.5*	5.5*	70*	52*	18
Average	LC-8	1025	6.4	23	55	0.3	57	0.2	0.1	283	677	(394)
7/20/72	LC-9	303	7.4	30	120	0.0	70	0.1	0.0	110	436	(326)
8/11/72	LC-9	190	7.9	4	104	0.4	70	0.1	0.0	9	237	(228)
Average	LC-9	247	7.7	17	112	0.2	70	0.1	0.0	50	332	(282)
7/20/72	LC-10	245	6.6	18	54	0.0	14	0.3	0.1	53	159	(106)
8/11/72	LC-10	290	6.7	2	46	0.2	8	0.2	0.2	7	160	(153)
Average	LC-10	268	6.7	10	50	0.1	11	0.3	0.2	32	161	(129)
7/20/72	LC-11	208	6.3	24	56	0.0	125	0.1	0.2	60	140	(80)
8/11/72	LC-11	120	6.7	2	54	0.6	125	0.1	0.2	3	77	(74)
Average	LC-11	144	6.5	13	55	0.3	125	0.1	0.2	22	95	(73)

TABLE 5 Cont'd.
LOST CREEK
SUPPLEMENTARY WATER QUALITY DATA
ACKENHEIL AND ASSOCIATES GEO SYSTEMS, INC.

Date	Station	Flow gpm	pH	Concentrations, mg/l						Loads, lbs/day		
				Acid	Alkalinity	Aluminum	Sulfate	Iron	Manganese	Acid	Alkalinity	Net-Acid
7/20/72	LC-12	85	6.5	8	52	0.0	8	0.2	0.4	8	53	(45)
8/11/72	LC-12	60	7.1	12	58	0.4	16	0.1	0.2	8	41	(33)
Average	LC-12	73	6.8	10	55	0.2	12	0.2	0.3	9	48	(39)
7/20/72	LC-13	302	6.7	12	46	0.1	82	0.1	0.2	43	167	(124)
8/11/72	LC-13	440	7.1	22	40	0.0	72	0.2	0.2	116	211	(95)
8/30/72	LC-13	11*	6.4*	40*	54*	0.1	140*	0.2	0.1	5*	7*	(2)*
Average	LC-13	371	6.9	17	43	0.1	77	0.2	0.2	76	191	(115)*
7/20/72	LC-14	293	6.5	14	52	0.0	120	0.3	0.5	49	183	(134)
8/11/72	LC-14	400	6.3	22	44	0.0	90	0.2	0.4	105	211	(106)
8/30/72	LC-14	3*	6.6	22	38*	0.5	600*	0.1	1.5*	1*	1*	0
Average	LC-14	347	6.5	19	48	0.0	105	0.2	0.5	80	200	(120)
7/20/72	LC-15	116	6.0	20	58	0.0	180	0.3	1.0	27	81	(54)
8/11/72	LC-15	240	6.4	14	50	0.4	150	0.2	0.6	40	144	(104)
8/30/72	LC-15	2*	6.4	26*	134*	0.3	300*	0.2	3.0*	0*	2*	(2)*
Average	LC-15	178	6.3	17	54	0.2	165	0.2	0.8	36	115	(79)

Parentheses Indicates Net Alkaline Load

*Indicates Value Has Been Excluded From Calculation of Average

TABLE 6
SOURCE 62062
SUPPLEMENTARY WATER QUALITY DATA
ACKENHEIL AND ASSOCIATES GEO SYSTEMS, INC.

Date	Station	Flow	pH	Concentrations, mg/l						Loads, lbs/day		
				Acid	Alkalinity	Aluminum	Sulfate	Iron	Manganese	Acid	Alkalinity	Net-Acid
7/21/72	62062	450	2.9	428	0	14.0	1175	65.0	2.5	2311	0	2311
8/30/72	62062	107*	2.3	378	0	16.5	1650	72.5	3.0	485	0	485
verage	62062	450	2.6	403	0	15.3	1413	68.8	2.8	2176	0	2176

*Indicates Value Has Been Excluded From
Calculation of Average

APPENDIX B

TABLE 1
BROWN'S CREEK AND LOST CREEK
ESTIMATED TREATMENT COSTS

I. LIME NEUTRALIZATION TREATMENT COSTS

A. Plant For Source 62062

1. Basis: Q = 450 gpm or .648 MGD
Net Acidity of 403 mg/l
Sludge Disposal by Lagoon

2. Capital Cost: Formula based on Gibbs and Hill data (October 24, 1972 letter to Dr. David R. Maneval)

Installed Cost = $350,000 Q (MGD)$^{.72}$

= $350,000 (.648)$^{.72}$

= $256,000

Includes 25 - 30% for purchase of land, engineering, design, etc.

3. Operating Cost: (Gibbs and Hill, October 24, 1972)

Lime @ $25/ton-acidity for 397 tons-acidity/yr.	$ 9,900
Labor @ 3.5% of Installed Cost	$ 9,000
Maintenance @ 5.0% of Installed Cost	$12,800
Power @ 1.5% of Installed Cost	$ 3,800
Total Annual Operating Cost	$35,500
Operating Cost Per 1000 Gallons Treated =	$0.15

B. Plant For SP-3A

1. Basis :

Q = 150 gpm or .216 MGD
Net Acidity of 454 mg/l
Sludge Disposal by Lagoon

2. Capital Cost:

Installed Cost = $350,000 Q (MGD)$^{.72}$

= $350,000 (.216)$^{.72}$

= $116,000

Includes 25 - 30% for purchase of land, engineering, design, etc.

3. Operating Cost:

Lime @ $25/ton-acidity for 149 tons-acidity/yr.	$ 3,700
Labor @ 3.5% of Installed Cost	$ 4,100
Maintenance @ 5.0% of Installed Cost	$ 5,800
Power @ 1.5% of Installed Cost	$ 1,700
Total Annual Operating Cost	$15,300
Operating Cost Per 1000 Gallons Treated =	$0.19

C. Combined Plant For Source 62062 and SP-3A Located At Source 62062

1. Basis:

Q = 600 gpm or .864 MGD
Net Acidity of 425 mg/l
Sludge Disposal by Lagoon

2. Capital Cost:

Installed Cost = $350,000 Q (MGD)$^{.72}$

= $350,000 (.864)$^{.72}$

= $315,000

Includes 25 - 30% for purchase of land, engineering, design, etc.

Collection System (lines and pumping station) = $100,000

Includes 25% for engineering, design, etc.

Total Capital Cost = $415,000

3. Operating Cost:

Lime @ $25/ton-acidity for 558 tons-acidity/yr.	$ 14,000
Labor @ 3.5% of Installed Cost	$ 11,000
Maintenance @ 5.0% of Installed Cost	$ 15,800
Power @ 1.5% of Installed Cost	$ 4,700
Maintenance of Collection System @ 5.0% of $100,000	$ 5,000
Total Annual Operating Cost	$ 50,500
Operating Cost Per 1000 Gallons Treated =	$0.16

II. ION EXCHANGE TREATMENT COSTS

A. Plant For Source 62062

1. Basis: Q = 450 pgm or .648 MGD

2. Capital Cost: Based on estimates obtained from "Engineering Economic Study of Mine Drainage Control Techniques" for ARC by C. W. Rice, 1969 and updated to 1972 technology levels.

Installed Cost = $830,000

Includes 35% for land, engineering, design, buildings, etc.

3. Operating Cost: Based on same reference as capital costs.

Total Annual Operating Cost	$239,000
Operating Cost per 1000 Gallons Product Water	$1.00

B. Plant For SP-3A

1. Basis:	Q = 150 gpm or .648 MGD		
2. Capital Cost:	Installed Cost = $470,000		
	Includes 35% for land, engineering, design, buildings, etc.		
3. Operating Cost:	Total Annual Operating Cost		$140,000
	Operating Cost Per 1000 Gallons Product Water	=	$1.80

C. Combined Plant For Source 62062 And SP-3A Located At Source 62062

1. Basis:	Q = 600 gpm or .864 MGD		
2. Capital Cost:	Installed Cost of Plant		$950,000
	Includes 35% for land, engineering, design, buildings, etc.		
	Collection System (lines and pumping station)		$100,000
	Includes 25% for engineering design, etc.		
	Total Capital Cost	=	$1,050,000
3. Operating Cost:	Annual Operating Cost For Plant		$276,000
	Operating Cost of Plant Per 1000 Gallons Product Water		$0.87
	Maintenance of Collection System @ 5.0% of $100,000		$ 5,000
	Total Annual Operating Cost	=	$281,000

III. REVERSE OSMOSIS TREATMENT COSTS

A. Plant for Source 62062

1. Basis: Q = 450 gpm or .648 MGD
TDS = 1500 ppm
With Lime Neutralization of the Acid Brine

2. Capital Cost: Based on estimates obtained from "Reverse Osmosis Demineralization of Acid Mine Drainage" for EPA by the Ecology Division, 1972, and adjusted for specific plant volumes.

Installed Cost = $570,000

Includes 35% for land, engineering, design, buildings, etc.

3. Operating Cost: Based on same reference as capital costs.

Total Annual Operating Cost	$142,000
Operating Cost Per 1000 Gallons Product Water	$0.60

Includes chemical additives, reverse osmosis modules, power, maintenance, materials labor, etc.

B. Plant For SP-3A

1. Basis: Q - 150 GPM or .216 MGD
TDS = 1500 ppm
With Lime Neutralization of the Acid Brine

2. Capital Cost: Installed Cost = $320,000

Includes 35% for land, engineering, design, buildings, etc.

3. Operating Cost:	Total Annual Operating Cost	$84,000
	Operating Cost Per 1000 Gallons Product Water	$1.06
	Includes chemical additives, reverse osmosis modules, power, maintenance, materials, labor, etc.	

C. Combined Plant For Source 62062 and SP-3A Located At Source 62062

1. Basis:	Q = 600 gpm or .864 MGD TDS = 1500 ppm With Lime Neutralization of the Acid Brine	
2. Capital Cost:	Installed Cost of Plant	$650,000
	Includes 35% for land, engineering, design, etc.	
	Collection System (lines and pumping station)	$100,000
	Includes 25% for engineering, desgin, etc.	
	Total Capital Cost	$750,000
3. Operating Cost:	Total Annual Plant Operating Cost	$164,000
	Operating Cost of Plant Per 1000 Gallons Product Water	$0.87
	Includes chemical additives, reverse osmosis modules, maintenance, materials, labor, etc.	
	Maintenance of Collection System @ 5.0% of $100,000	$ 5,000
	Total Annual Operating Cost	$169,000

TABLE 2
LOST CREEK AREA
ESTIMATED SEWAGE TREATMENT COSTS

I. SEWAGE TREATMENT PLANT AND COLLECTION SYSTEMS

1. Basis:

1985 projected population for Lost Creek is 750 - 1500.

1500 population @ 100 GPD/capita = 150,000 GPD

Typical Municipal Waste: Use activated sludge - type secondary treatment (extended aeration).

Sewage treatment plant would also handle acid brine waste from a reverse osmosis treatment plant located in the Brown's Creek area.

2. Capital Cost:

a. Sewage Treatment Plant Cost: Formula based on Gibbs and Hill data (October 24, 1972 letter to Dr. David R. Maneval)

$Million of Plant Cost = $1.05 \times MGD^{.71}$

$= 1.05 \times (.150)^{.71}$

Or Plant Cost = $273,000

Exclusive of interceptors and outfalls.

b. Interceptor Sewer Cost:

3.75 miles, 8" line at $8/ft.	$158,000
Pumping Station	$ 15,000
25% for engineering, design, etc.	$ 44,000
Total Cost of Interceptor Sewer	$217,000

c. Brine Transportation Line Cost: Based on estimates obtained from "Concentrated Mine Drainage Disposal into Sewage Treatment Systems" for EPA by Environmental Research and Applications, Inc. 1971

		15,000 GPD, 4.5 miles of line, 4" reinforced plastic pipe @ $1.40/ft.	$33,000
		Pumping Station	$ 7,000
		Excavation and Backfilling	$ 5,000
		Addition for engineering, design, etc.	$ 8,000
		Total Cost of Brine Pipeline	$53,000
	d.	Total Capital Cost of Plant and Lines	$543,000
3. Operating Cost:	a.	Plant Operating Cost: Same reference used as for capital cost.	
		Annual Cost of Operation and Maintenance	= 10% of Installed Cost
		=	$27,300
	b.	Maintenance of Interceptor Lines @ $40/day	$15,000
	c.	Maintenance of Brine Pipeline: Same reference as for capital cost for pipeline. Maintenance @ $25/day	$ 9,200
	d.	Total Annual Operating Cost of Plant and Lines	$51,500

TABLE 3
BROWN'S CREEK AND LOST CREEK
LISTING OF PROPERTY OWNERS
IN RECLAMATION AREAS

SP-3A RECLAMATION AREA

Tax Map	Parcel	Owner	Record
367	30	Maxwell, Frank J. & W. B. Mount Clare, West Virginia	DBV 309 Pg. 494
367	31	McGee, L. S. Mount Clare, West Virginia	DBV 641 Pg. 512
367	32, 39	Brown's Creek Corporation Mount Clare, West Virginia	DBV 787 Pg. 543
367	38	Dawson, Lovie Miller Mount Clare, West Virginia	DBV 756 Pg. 107
367	49	Groves, Grace Lost Creek, West Virginia	DBV 464 Pg. 309
367	1,2,3,4 (Sheet 20-27)	Adams, Lawrence Arthur Lost Creek, West Virginia	DBV 544, 574 Pp. 467, 103
367	10,11,12,13 (Sheet 20-07)	Murray, Carl Robert Sr. Mount Clare, West Virginia	DBV 876 Pg. 385
367	14 (Sheet 20-07)	Hartley, Mary E. Lost Creek, West Virginia	DBV 574 Pg. 370
367	15 (Sheet 20-07)	Hartley, Harold Lee Lost Creek, West Virginia	DBV 913 Pg. 394
367	16 (Sheet 20-07)	Nutter Fort Union Mission Church Lost Creek, West Virginia	DBV 884 Pg. 433
367	17, 18, 19 (Sheet 20-07)	Cottrill, Jerome F. Lost Creek, West Virginia	DBV 305 Pg. 319
367	21, 22, 25 (Sheet 20-07)	Jefferies, John & Hilda Mount Clare, West Virginia	DBV 994 Pg. 583
367	23 (Sheet 20-07)	Jefferies, Hilda Mount Clare, West Virginia	DBV 900 Pg. 401
367	26, 27 (Sheet 20-07)	Thompson, Harold & Helen Mount Clare, West Virginia	DBV 994 Pg. 735
367	28, 29 (Sheet 20-07)	Bonnell, Bertie & John Lost Creek, West Virginia	DBV 542 Pg. 361

Table 3

Tax Map	Parcel	Owner	Record
367	66 (Sheet 20-07)	Malindzak, Mary P. & Andrew M. Mount Clare, West Virginia	DBV 555 Pg. 311
367	69, 70, 71 (Sheet 20-07)	Murphy, Hallie D. & Ruth L. Mount Clare, West Virginia	DBV 480 Pg. 195
367	72, 73, 74 (Sheet 20-07)	Wimer, William C. & Dencie L. Mount Clare, West Virginia	DBV 813 Pg. 108
367	75, 78 (Sheet 20-07)	Stout, James E. Mount Clare, West Virginia	DBV 742 Pg. 315
367	79,80,81,95 (Sheet 20-07)	Murphy, Ruth L. Lost Creek, West Virginia	DBV 937 Pg. 336
367	82,83,84,85 (Sheet 20-07)	Gordon, Frank & Pansy Mount Clare, West Virginia	DBV 965 Pg. 551
367	86,87 (Sheet 20-07)	Carr, Harry C. & Maggie L. Lost Creek, West Virginia	DBV 298 Pg. 197
367	88,89,90,91 (Sheet 20-07)	Carr, William S. & Marjorie E. Mount Clare, West Virginia	DBV 925 Pg. 532
367	92,93,94 (Sheet 20-07)	Wimer, Daisy & Dorothy J. Mount Clare, West Virginia	DBV 940 Pg. 232
367	96,97,98,99 (Sheet 20-07)	Richards, Ronald L. & Dula R. Mount Clare, West Virginia	DBV 864 Pg. 431
367	100,100,102, 103,104,105 (Sheet 20-07)	Greaver, Clifton Mount Clare, West Virginia	DBV 857 Pg. 145
367	106,107,108 (Sheet 20-07)	Romano, Rose Mount Clare, West Virginia	DBV 414 Pg. 423
367	109,110,111, 112,113 (Sheet 20-07)	Roth, Charles J. & Doris J. Mount Clare, West Virginia	DBV 914 Pg. 99
367	114,116,117, 118,119,122 123,124,125 126,127 (Sheet 20-07)	Siranni, Frank, et al Mount Clare, West Virginia	DBV 67 Pg. 624
367	115 (Sheet 20-07)	Siranni, Salvatore Mount Clare, West Virginia	DBV 67 Pg. 624

Table 3

Tax Map	Parcel	Owner	Record
367	120,121 (Sheet 20-07)	Romano, Biago Mount Clare, West Virginia	DBV 543 Pg. 259
367	128,129,130 133,134,135 136 (Sheet 20-07)	Romano, Pete Robert, et al Mount Clare, West Virginia	DBV 389,287,231 Pp. 296, 57,263
367	132 (Sheet 20-07)	Romano, Rosario Mount Clare, West Virginia	DBV 231 Pg. 263
367	137,138 (Sheet 20-07)	Lawson, Mary Jane Mount Clare, West Virginia	DBV 897 Pg. 492
367	139 (Sheet 20-07)	Clayton, Carl D. & Florence M. Mount Clare, West Virginia	DBV 868 Pg. 111
367	140 (Sheet 20-07)	Shaw, Jasper N. Est. Mount Clare, West Virginia	DBV 172 Pg. 417
367	141 (Sheet 20-07)	Jackson, Willard & Marjorie Mount Clare, West Virginia	DBV 902 Pg. 291
367	142 (Sheet 20-07)	Trotter, William Mount Clare, West Virginia	DBV 851 Pg. 328
367	143 (Sheet 20-07)	Bragg, Frank L., Sr. Lost Creek, West Virginia	DBV 710 Pg. 468
367	144 (Sheet 20-07)	Bragg, Chloea Lost Creek, West Virginia	DBV 828 Pg. 55
367	145 (Sheet 20-07)	Sabatelli, Lenoard et al Mount Clare, West Virginia	DBV 731 Pg. 344
367	146 (Sheet 20-07)	Rhoden, Phoebe Mount Clare, West Virginia	DBV 495 Pg. 152
367	147, 148 (Sheet 20-07)	Dodd, Clyde M. & Velma J. Mount Clare, West Virginia	DBV 942, 906 Pp. 310, 119
367	149 (Sheet 20-07)	Sabatelli, Leonard J. Mount Clare, West Virginia	DBV 856 Pg. 489
367	150 (Sheet 20-07)	Markley, Robert J. Mount Clare, West Virginia	DBV 574 Pg. 97
367	151 (Sheet 20-07)	Markley, Hayward B. Mount Clare, West Virginia	DBV 719 Pg. 371
367	152 (Sheet 20-07)	Lowell, Chas. T. & Mae Mount Clare, West Virginia	DBV 755 Pg. 437

Table 3

Tax Map	Parcel	Owner	Record
367	153 (Sheet 20-07)	Knight, Argyle Mount Clare, West Virginia	
367	154 (Sheet 20-07)	Myers, Mary Mount Clare, West Virginia	DBV 580 Pg. 32
367	155 (Sheet 20-07)	Markley, Robert J., Jr. & Joyce Lost Creek, West Virginia	DBV 865 Pg. 409
367	156 (Sheet 20-07)	Markley, Mary M. & Leroy Mount Clare, West Virginia	DBV 574 Pg. 95
367	157 (Sheet 20-07)	Romano, Leonard Mount Clare, West Virginia	DBV 660 Pg. 321
367	159 (Sheet 20-07)	Kniska, Andrew C. Mount Clare, West Virginia	DBV 971 Pg. 270
367	1 (Sheet 20-09)	Bragg, Samuel R. & Hazel P. Lost Creek, West Virginia	DBV 584 Pg. 143
367	2 (Sheet 20-09)	Wagner, John Ellis Mount Clare, West Virginia	DBV 944 Pg. 615
367	4 (Sheet 20-09)	McCullough, Cindy, et al Mount Clare, West Virginia	DBV 685 Pg. 503
367	5 (Sheet 20-09)	Rowe, Carrie Virginia Mount Clare, West Virginia	DBV 591 Pg. 362
367	6, 7 (Sheet 20-09)	Rowe, Bacil Lee Mount Clare, West Virginia	DBV 919 Pg. 168
367	8 (Sheet 20-09)	Wetzel, Lee R. & Frances Mount Clare, West Virginia	DBV 769 Pg. 326
367	9 (Sheet 20-09)	Brady, Alma Lost Creek, West Virginia	DBV 699 Pg. 410
367	10, 11 (Sheet 20-09)	Wetzel, George O., et al Lost Creek, West Virginia	DBV 858 Pg. 370
367	12 (Sheet 20-09)	Shaw, Ella G. Mount Clare, West Virginia	DBV 290 Pg. 1
367	13 (Sheet 20-09)	Lowell, Beatrice Chevront Mount Clare, West Virginia	DBV 511 Pg. 108

Table 3

Tax Map	Parcel	Owner	Record
367	14 (Sheet 20-09)	Salate, Mary & Rocco Mary Soletti - (Deceased) Mount Clare, West Virginia	1970 Land Book Pg. 448
367	15 (Sheet 20-09)	Salate, Mary C. & William P. Gonosoreik Mount Clare, West Virginia	DBV 938 Pg. 157
367	16, 17 (Sheet 20-09)	Salate, Mary and Rocco - Mary Soletti Mount Clare, West Virginia	1970 Land Book Pp. 488
367	18 (Sheet 20-09)	Gowers, Harry & Elva Mount Clare, West Virginia	DBV 939 Pg. 15
367	19 (Sheet 20-09)	Cork, Creed R. Mount Clare, West Virginia	DBV 612 Pg. 478
367	20 (Sheet 20-09)	Romano, Carmine Hrs. Mount Clare, West Virginia	DBV 538 Pg. 1
367	21 (Sheet 20-09)	Romano, Paul Mount Clare, West Virginia	DBV 619 Pg. 384
367	22 (Sheet 20-09)	Sumpter, Barbara Mount Clare, West Virginia	DBV 667 Pg. 462
367	23 (Sheet 20-09)	Romano, Mary & Joe Mount Clare, West Virginia	DBV 768 Pg. 341
367	24 (Sheet 20-09)	Rinehart, Marvin. Wm. & Lovie W. Mount Clare,West Virginia	DBV 543 Pg. 261
367	25 (Sheet 20-09)	Cork, Creed, R. Mount Clare, West Virginia	DBV 161 Pg. 498

Table 3

SP-4A RECLAMATION AREA:

Tax Map	Parcel	Owner	Record
387	1.2	Cork, Perrcy W. Mount Clare, West Virginia	DBV 634, 726 Pp. 236, 539
387	3	Livesay, J. W. Mount Clare, West Virginia	DBV 363 Pg. 472
387	15.1	Ranski, Frona & Joseph C. Frazier Mount Clare, West Virginia	DBV 949 Pg. 188
387	15.2	Mano, Dominick & May L. Mount Clare, West Virginia	DBV 941 Pg. 580
387	1 (Sheet 20-11)	Kreiling, Wm. J. & Virginia E. Mount Clare, West Virginia	DBV 955 Pg. 100
387	2,3,4 (Sheet 20-11)	McDonald, Wm. G. & Nancy A. Mount Clare, West Virginia	DBV 826, 913 Pp. 113, 513
387	5 (Sheet 20-11)	Johnson, Annabe Miller Lost Creek, West Virginia	DBV 602 Pg. 270
387	6, 16 (Sheet 20-11)	Everett, James E. & Mollie Lost Creek, West Virginia	DBV 590 Pg. 373
387	7 (Sheet 20-11)	Crock, Robert Mount Clare, West Virginia	DBV 973 Pg. 433
387	8 (Sheet 20-11)	Perry, Katie M. Mount Clare, West Virginia	DBV 590 Pg. 331
387	9, 17 (Sheet 20-11)	Mano, Frank Mount Clare, West Virginia	DBV 768, 595 Pp. 330, 13
387	10 (Sheet 20-11)	Mano, Frank & Reva Mount Clare, West Virginia	DBV 941 Pg. 313
387	11 (Sheet 20-11)	Starr, Clyde & Katherine V. Mount Clare, West Virginia	DBV 590 Pg. 376
387	12 (Sheet 20-11)	Koch, Joseph & Victoria Lost Creek, West Virginia	DBV 724 Pg. 108
387	13 (Sheet 20-11)	Johnson, Robert D & Madeline A. Mount Clare, West Virginia	DBV 943 Pg. 161
387	14 (Sheet 20-11)	Skinner, Don P. & Antionette Mount Clare, West Virginia	DBV 877 Pg. 544
387	15 (Sheet 20-11)	Loria, Domineck & Jenny Mount Clare, West Virginia	DBV 590 Pg. 346

Table 3

Tax Map	Parcel	Owner	Record
387	18 (Sheet 20-11)	Lovett, Bernice E. Mount Clare, West Virginia	DBV 693 Pg. 295
387	19 (Sheet 20-11)	Snyder Wm. E. Mount Clare, West Virginia	Pg. 429
387	20 (Sheet 20-11)	Mano, Anthony & Betty Lost Creek, West Virginia	DBV 867 Pg. 121
387	21 (Sheet 20-11)	Everitt, William L. & Helen L. Lost Creek, West Virginia	DBV 830 Pg. 191
387	22 (Sheet 20-11)	Burkhammer, Carl E. & Alma Lost Creek, West Virginia	DBV 590 Pg. 370
387	23 (Sheet 20-11)	Shepherd, James E. & Evla Mount Clare, West Virginia	DBV 647 Pg. 26
387	24 (Sheet 20-11)	Mano, Larry & Freda O. Mount Clare, West Virginia	DBV 590 Pg. 358
387	26 (Sheet 20-11)	Everett, Charles Lost Creek, West Virginia	DBV 897 Pg. 35
387	27, 32, 37 (Sheet 20-11)	Kreiling, Wm. J. & Virginia E. Mount Clare, West Virginia	DBV 955, 883 Pg. 100, 435
387	28 (Sheet 20-11)	Snyder, Vera & William Mount Clare, West Virginia	DBV 615 Pg. 47
387	29 (Sheet 20-11)	Mano, Dominick & May E. Mount Clare, West Virginia	DBV 590 Pg. 349
387	30 (Sheet 20-11)	Popovich, Nick Mount Clare, West Virginia	DBV 944 Pg. 7
387	31 (Sheet 20-11)	Trevision, George & Mary Mount Clare, West Virginia	DBV 590 Pg. 334
387	33 (Sheet 20-11)	Richards, Gail A. Mount Clare, West Virginia	DBV 830 Pg. 545
387	34, 36 (Sheet 20-11)	Leonard, Robert K. & Jeannette M. Mount Clare, West Virginia	DBV 909 Pg. 414
387	35 (Sheet 20-11)	Baltimore & Ohio Railroad Co. Mount Clare, West Virginia	DBV 740 Pg. 1

Table 3

Tax Map	Parcel	Owner	Record
387	38 (Sheet 20-11)	Hope Natural Gas Company Mount Clare, West Virginia	DBV 775 Pg. 397
387	39 (Sheet 20-11)	Monongahela Power Company Mount Clare, West Virginia	DBV 776 Pg. 36
387	41 (Sheet 20-11)	Sewell, Pocohantas Coal Company Lost Creek, West Virginia	DBV 703 Pg. 405
387	42 (Sheet 20-11)	Rogers, John William Mount Clare, West Virginia	DBV 718 Pg. 247
387	43 (Sheet 20-11)	M. E. Church Mount Clare, West Virginia	DBV 51 Pg. 174
387	44 (Sheet 20-11)	Trustees, M. E. Church Mount Clare, West Virginia	DBV 169 Pg. 254
387	45 (Sheet 20-11)	James, Jessie R. & Mucie Lost Creek, West Virginia	DBV 891 Pg. 75
387	46 (Sheet 20-11)	Livesay, Jas. W. Mount Clare, West Virginia	DBV 346 Pg. 115
387	47, 48 (Sheet 20-11)	James, Jessie & Mucie Mount Clare, West Virginia	DBV 611 Pg. 333
387	49 (Sheet 20-11)	James, Jessie R. Mount Clare, West Virginia	DBV 663 Pg. 529
387	50 (Sheet 20-11)	Hoffner, Katherine Mount Clare, West Virginia	DBV 57 Pg. 484
387	51 (Sheet 20-11)	Boggs, G. A. est Mount Clare, West Virginia	DBV 3838 Pg. 480

Table 3

LC-4A - RECLAMATION AREA

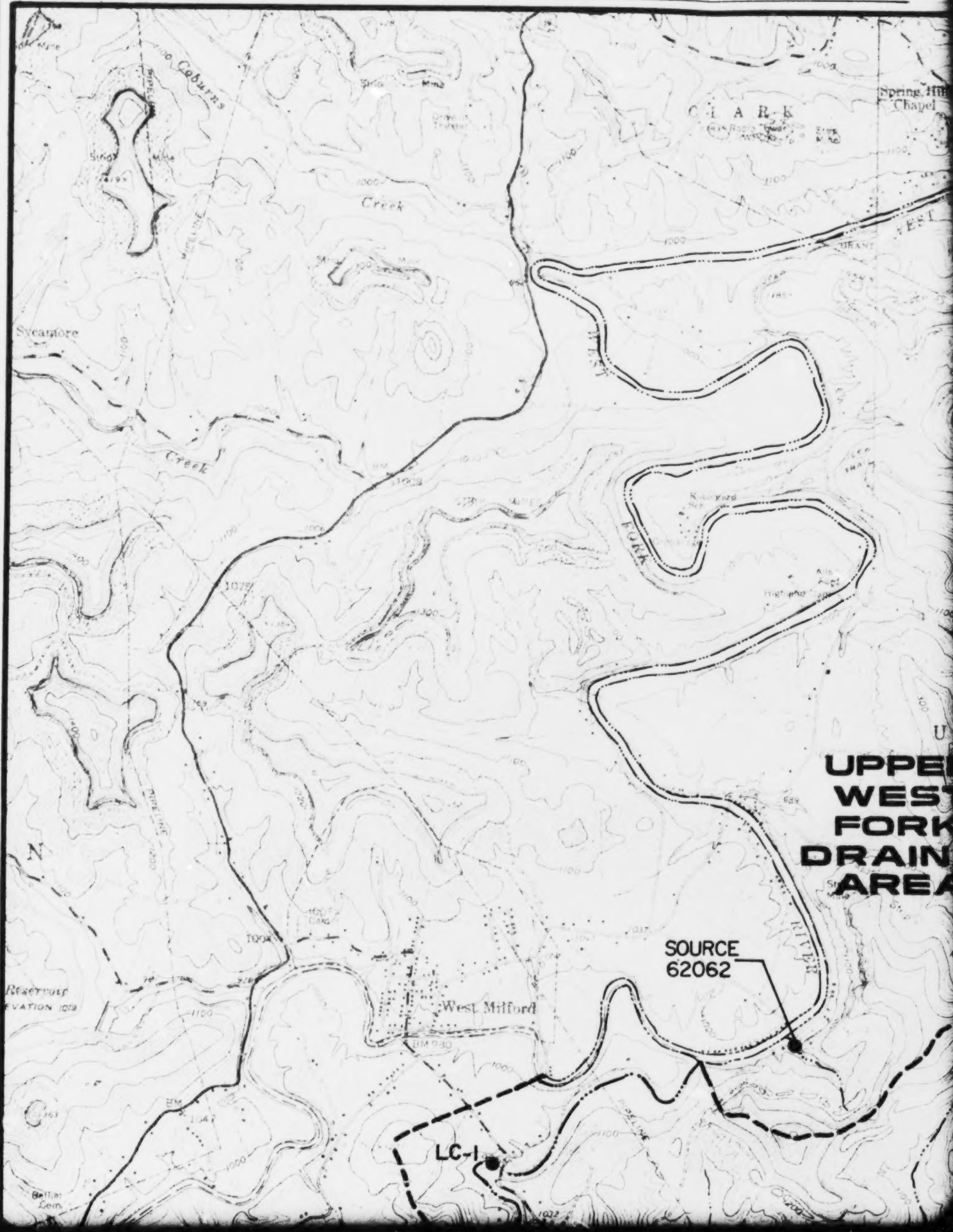
Tax Map	Parcel	Owner	Record
426	1,2,3,4, 14,15,16, 17,18,19, 25,27	Petitto Brothers, Inc. Lost Creek, West Virginia	DBV 892 Pg. 536, 583
426	6	Lowther, A. Lot and Susan Lost Creek, West Virginia	DBV 697 Pg. 197
426	7	Lowther, Susan E. et al Lost Creek, West Virginia	DBV 698 Pg. 575
426	21	Dillion, Okey E. & Irene Lost Creek, West Virginia	DBV 826 Pg. 7
426	22	Small, L. C. Lost Creek, West Virginia	DBV 722 Pg. 441
426	23	Small, Lawrence C. Lost Creek, West Virginia	DBV 667 Pg. 453
426	24	Small, L. Carl Lost Creek, West Virginia	DBV 915 Pg. 276
426	26	Small, Charles H. & Geneva Lost Creek, West Virginia	DBV 598 Pg. 28
386	35,36,37 38, 84.1 85, 102	Cork, Percy W.	DBV 585, 594, DBV 634, 720 pp. 236, 308, pp. 504, 505
386	84	Maxwell, Howard, Jackson	DBV 9 pg. 159

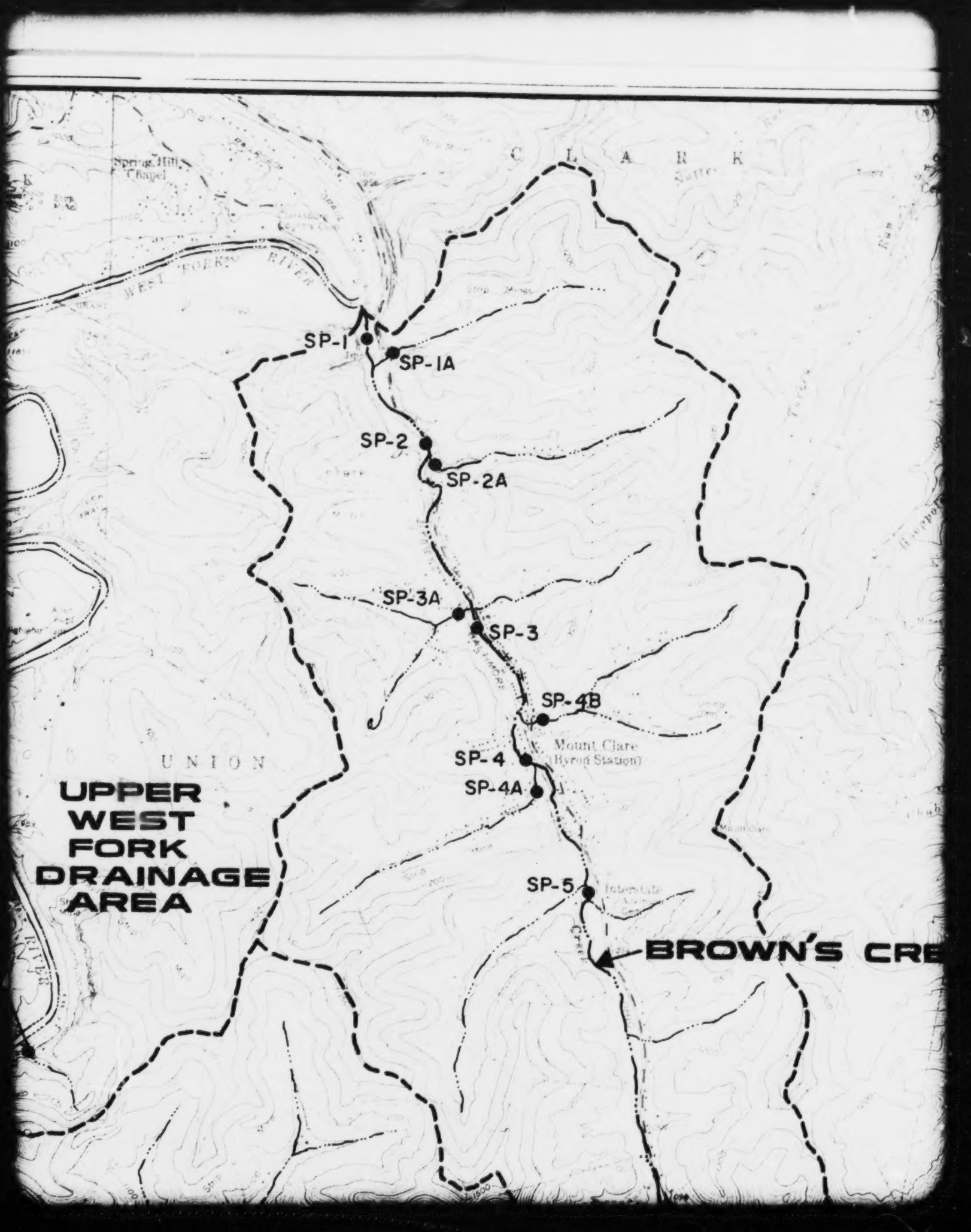
Table 3

SOURCE 62062 AREA

Tax Map	Parcel	Owner	Record
386	98, 113	White, Roscoe R. & Mabel West Milford, West Virginia	DBV 761 Pg. 117
386	99	Helmick, E. Stout West Milford, West Virginia	DBV 622 Pg. 257
386	114	Martin, Jack W. & Merle West Milford, West Virginia	DBV 941 Pg. 367
386	115, 116	Martin, Jack West Milford, West Virginia	DBV 803 Pg. 375
386	117,118,119	Reich, Charles E. & Margaret J. West Milford, West Virginia	DBV 950 Pg. 312
386	120,121,122	Valentine, Lula M. West Milford, West Virginia	DBV 756 Pg. 532
386	123,124	Valentine, Lula West Milford, West Virginia	DBV 715 Pg. 260
386	9	Stenger, Louis J. & John Earl Lost Creek, West Virginia	DBV 966 Pg. 105

APPENDIX C

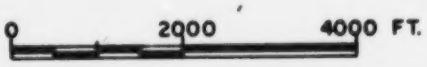

UPPER
WEST
FORK
DRAIN
AREA
SOURCE
62062
LC-1
West Milford
Sycamore
Creek
CLARK
Spring Hill
Chapel
Reservoir
ELEVATION 1019


SP-1
SP-1A
SP-2
SP-2A
SP-3A
SP-3
SP-4B
SP-4
SP-4A
SP-5
UPPER WEST FORK DRAINAGE AREA
BROWN'S CRE
CLARK
UNION
Mount Clare
(Byron Station)
WEST FORK RIVER

EVALUATION OF POLLUTION ABATEMENT TECHNIQUES OF LOST CREEK & BROWN'S CREEK WATERSHED WEST VIRGINIA FOR APPALACHIAN REGIONAL COMMISSION

FIGURE 4

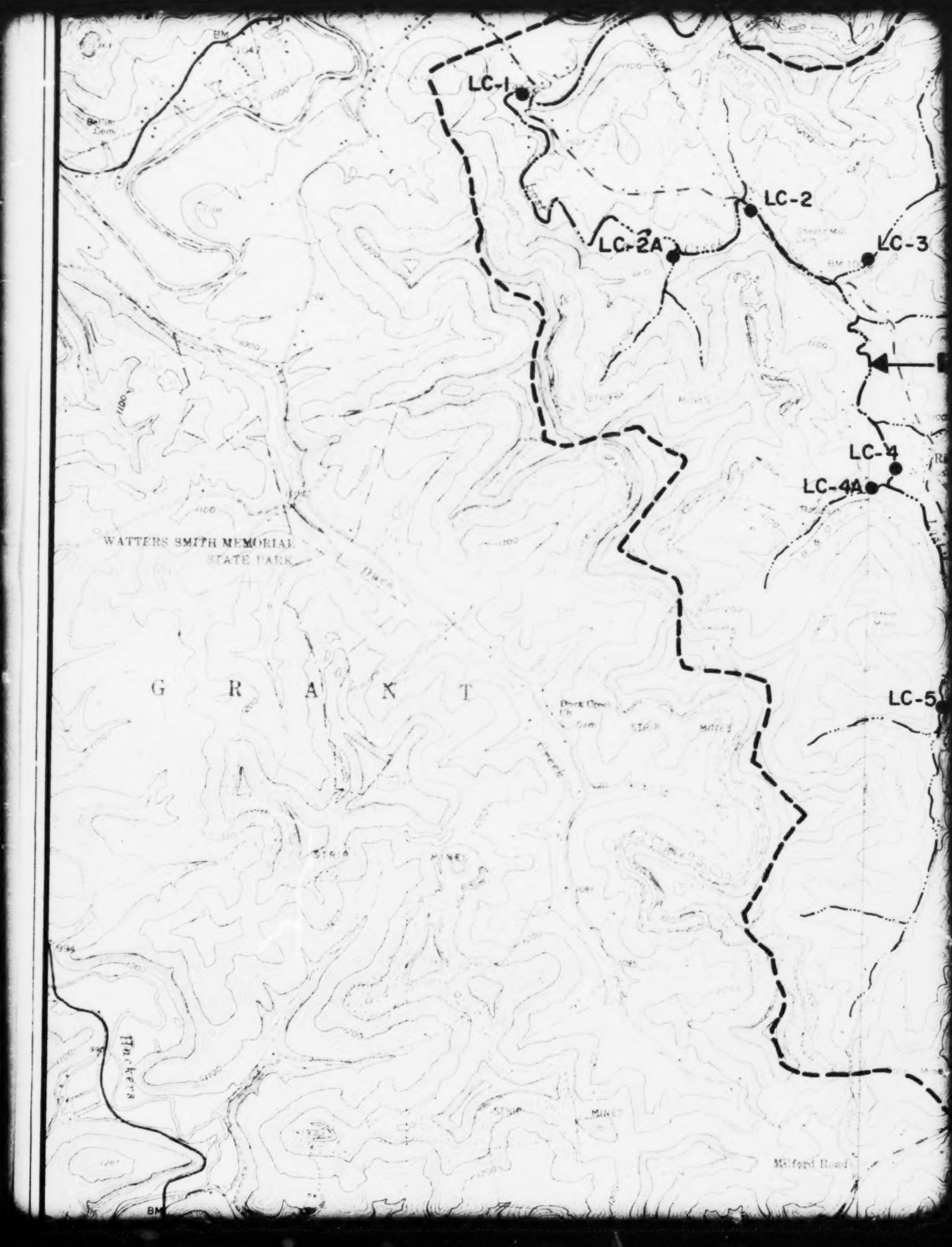
SAMPLING LOCATIONS

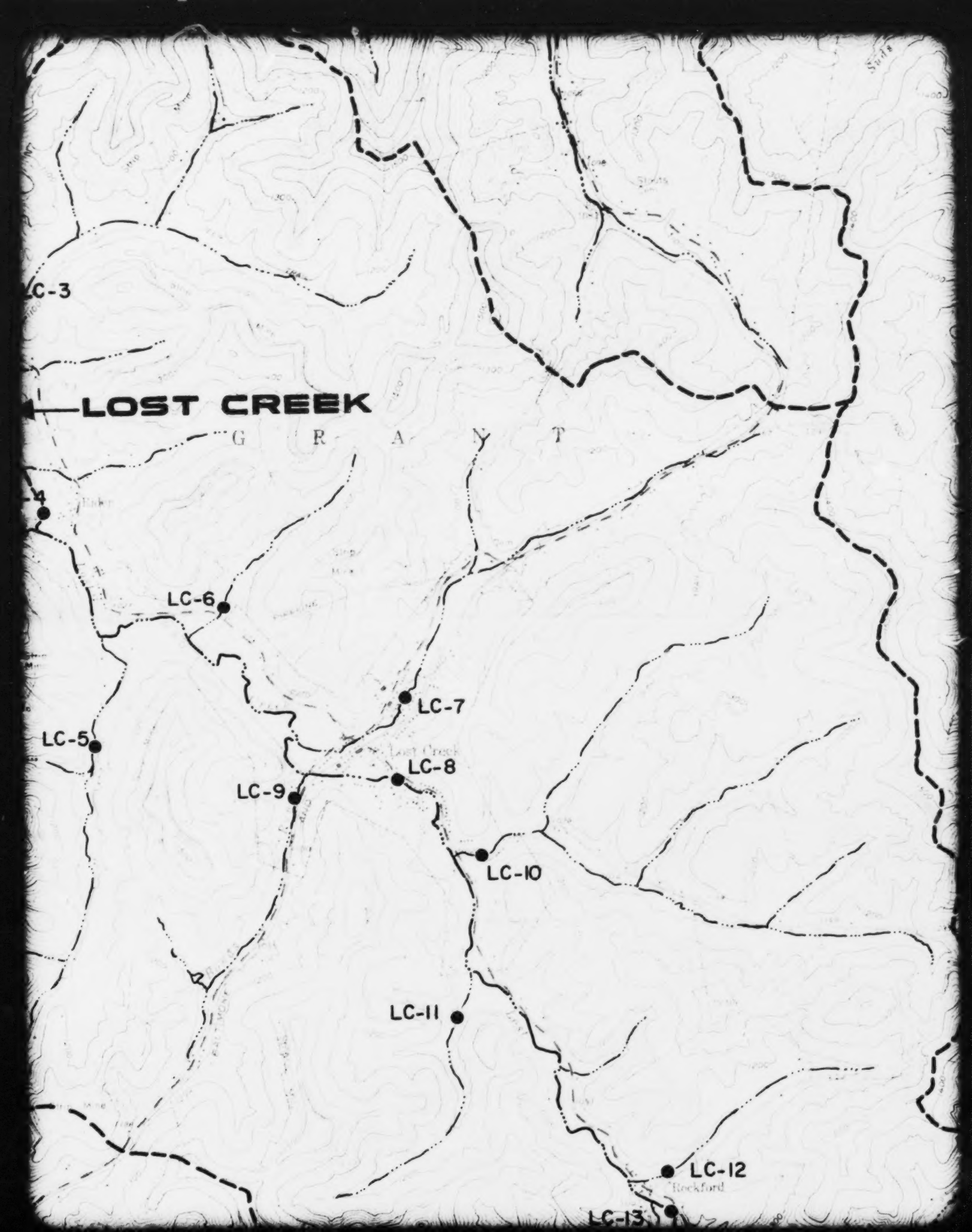


ACKENHEIL & ASSOCIATES
GEO SYSTEMS, INC. - CONSULTING ENGINEERS

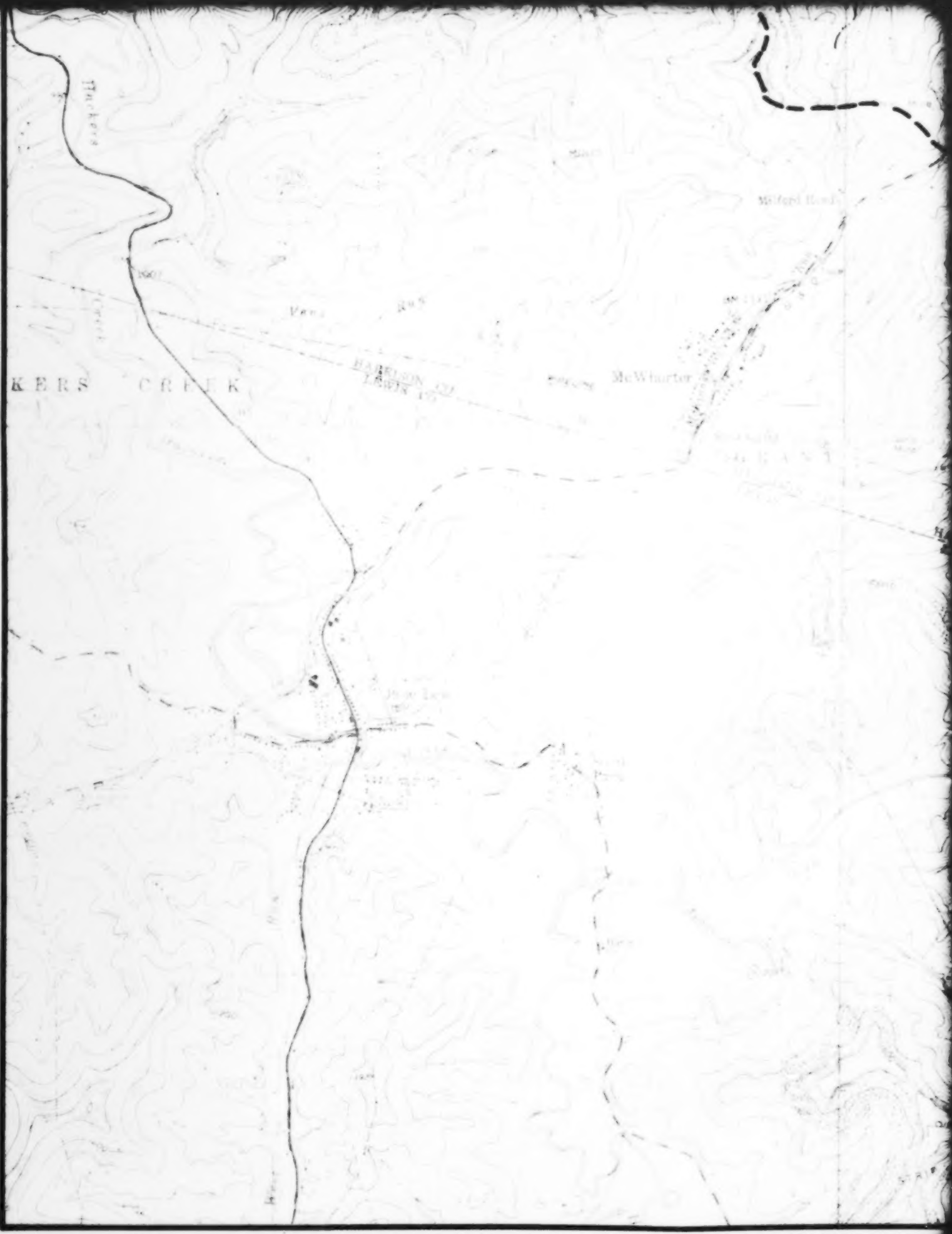
OWN'S CREEK

Craigmoor


LC-1
LC-2
LC-2A
LC-3
LC-4
LC-4A
LC-5
WATTERS SMITH MEMORIAL
STATE PARK
G R A N T
Milford Road

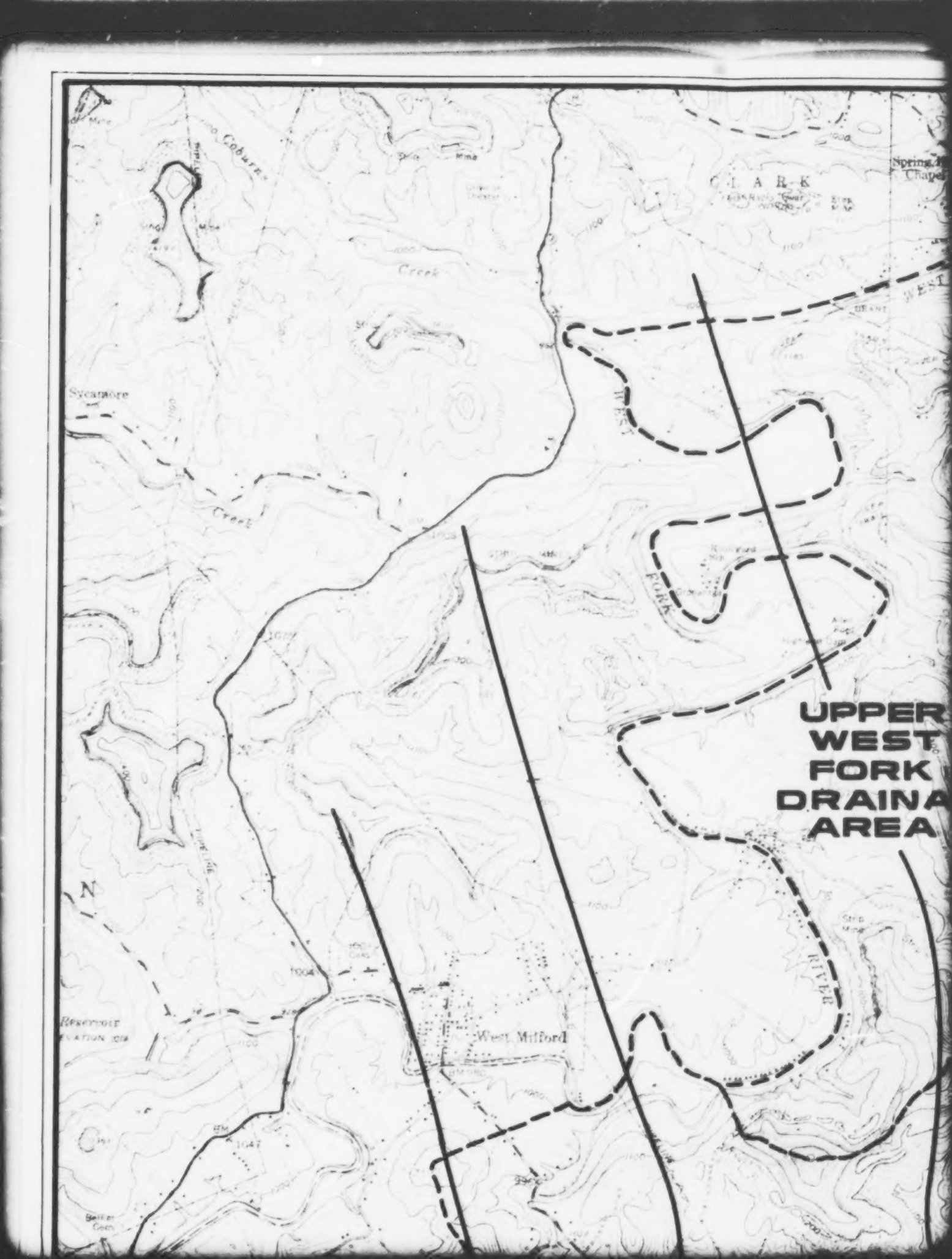

LC-3
LOST CREEK
GRANT
LC-6
LC-7
LC-5
LC-8
LC-9
LC-10
LC-11
LC-12
Rockford
LC-13

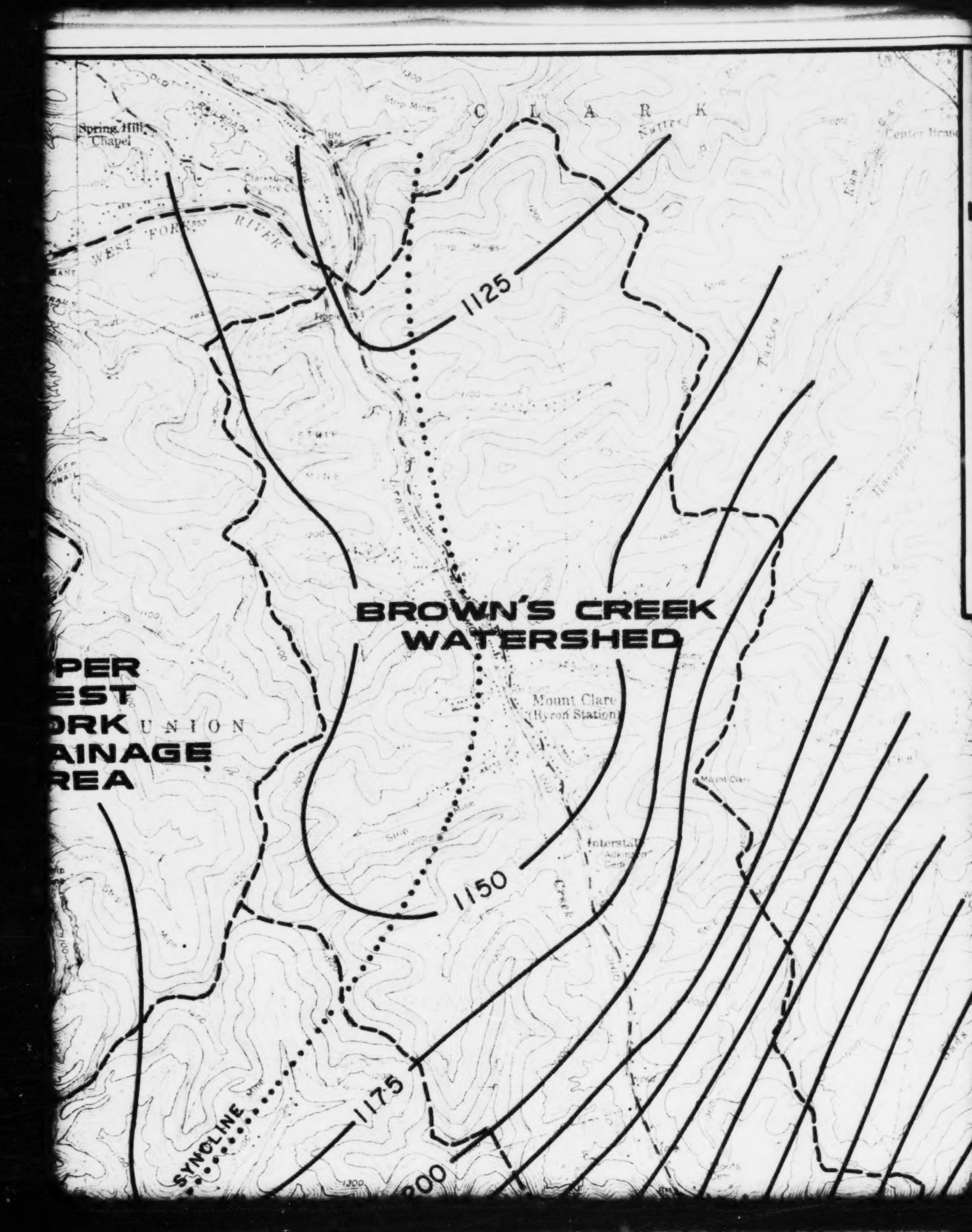
Craigmour
Run
Elk
E L K
Hastings
Run
LC-12

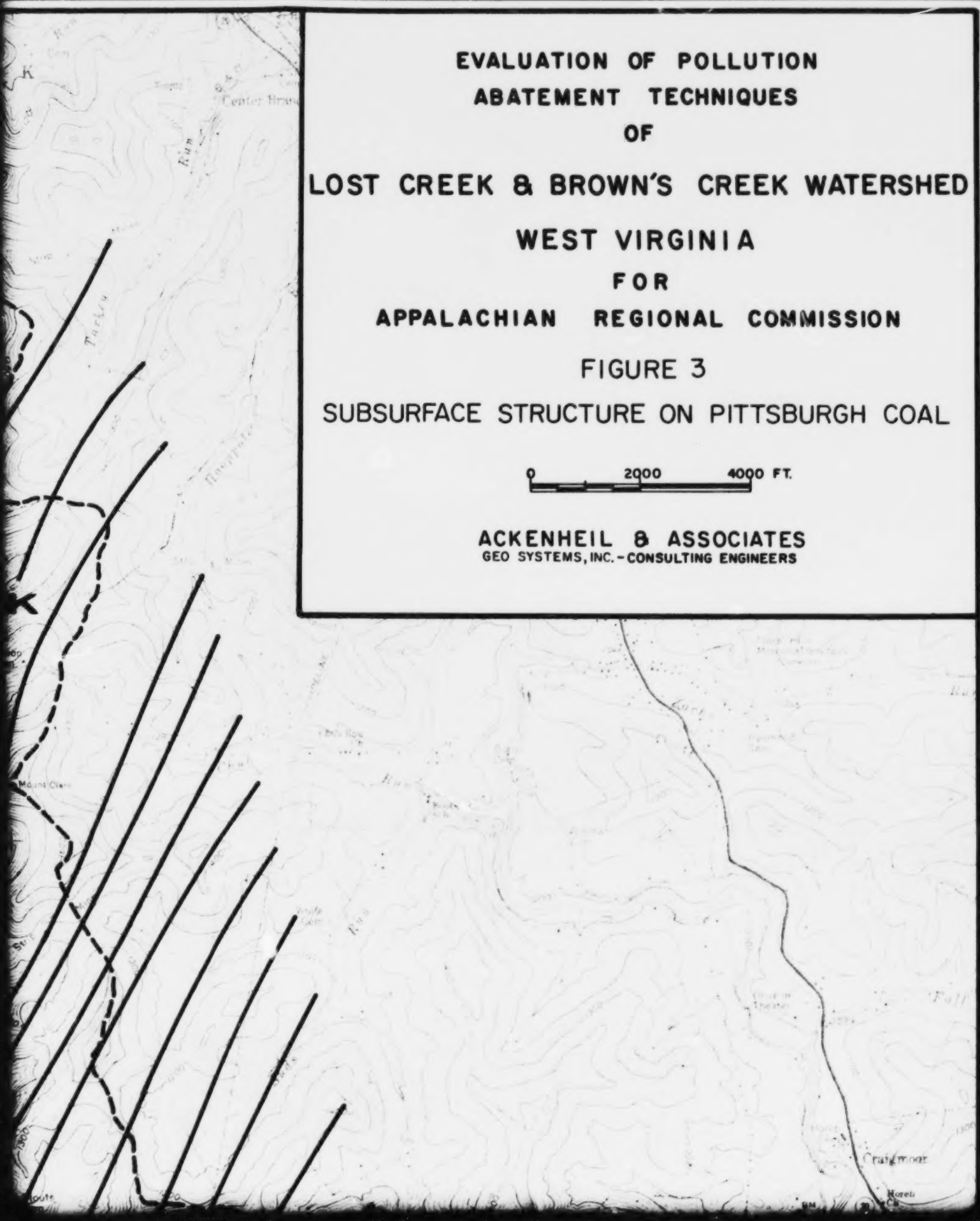

KERS CREEK

LC-11
LC-12
Rockford
LC-13
LC-14
LC-15
G R A N T
HARRISON CO
LEWIS CO

LC-12
LC-14
LC-15


CLARK
Sycamore
Creek
WEST
FORK
RIVER
UPPER
WEST
FORK
DRAINA
AREA
West Milford
N


BROWN'S CREEK
WATERSHED
PER
EST
ORK UNION
AINAGE
REA
1125
1150
1175
SYNCLINE
Spring Hill
Chapel
WEST FORK RIVER
Strip Mines
Mount Clare
(Byron Station)
Interstate
C L A R K



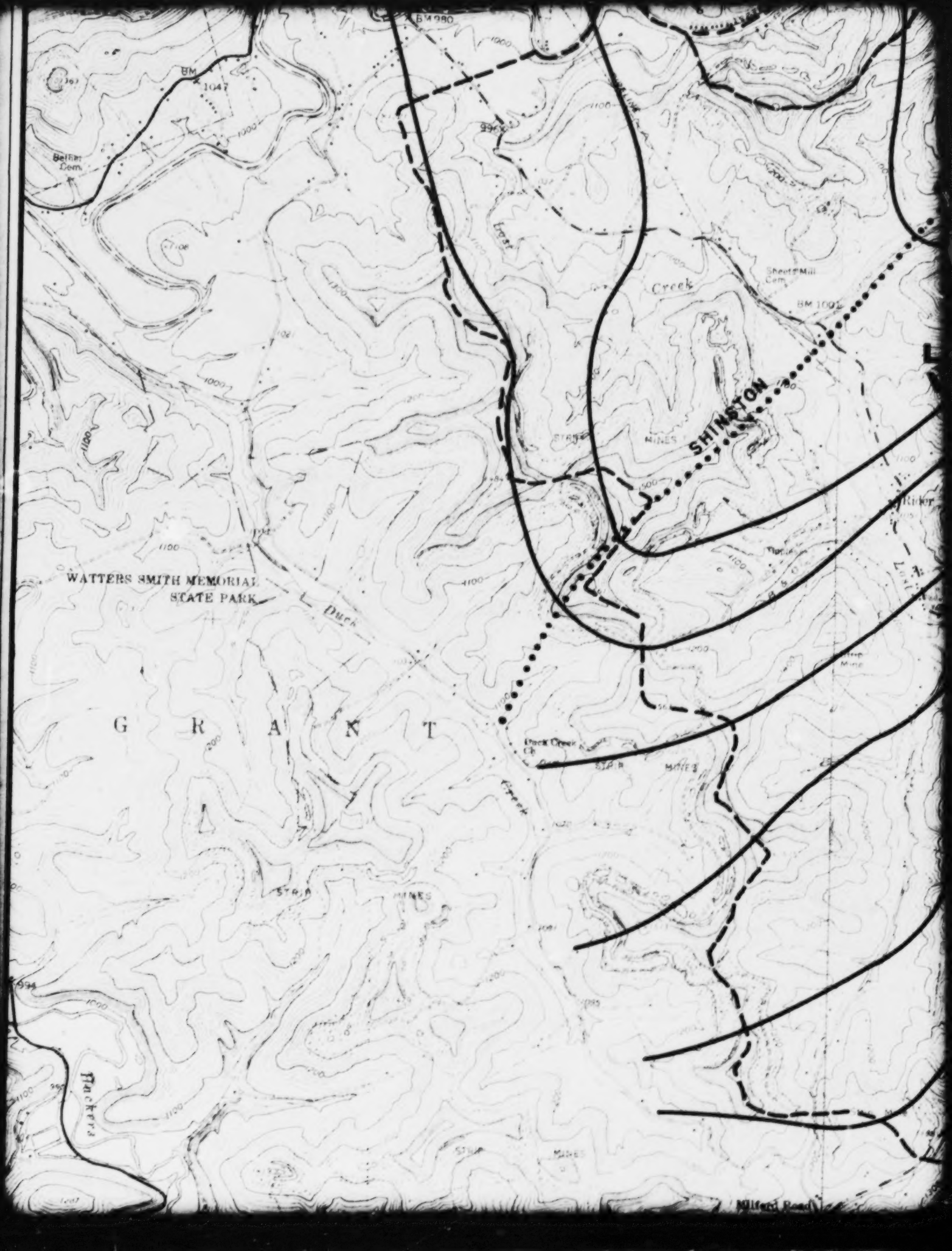
EVALUATION OF POLLUTION ABATEMENT TECHNIQUES OF LOST CREEK & BROWN'S CREEK WATERSHED WEST VIRGINIA FOR APPALACHIAN REGIONAL COMMISSION

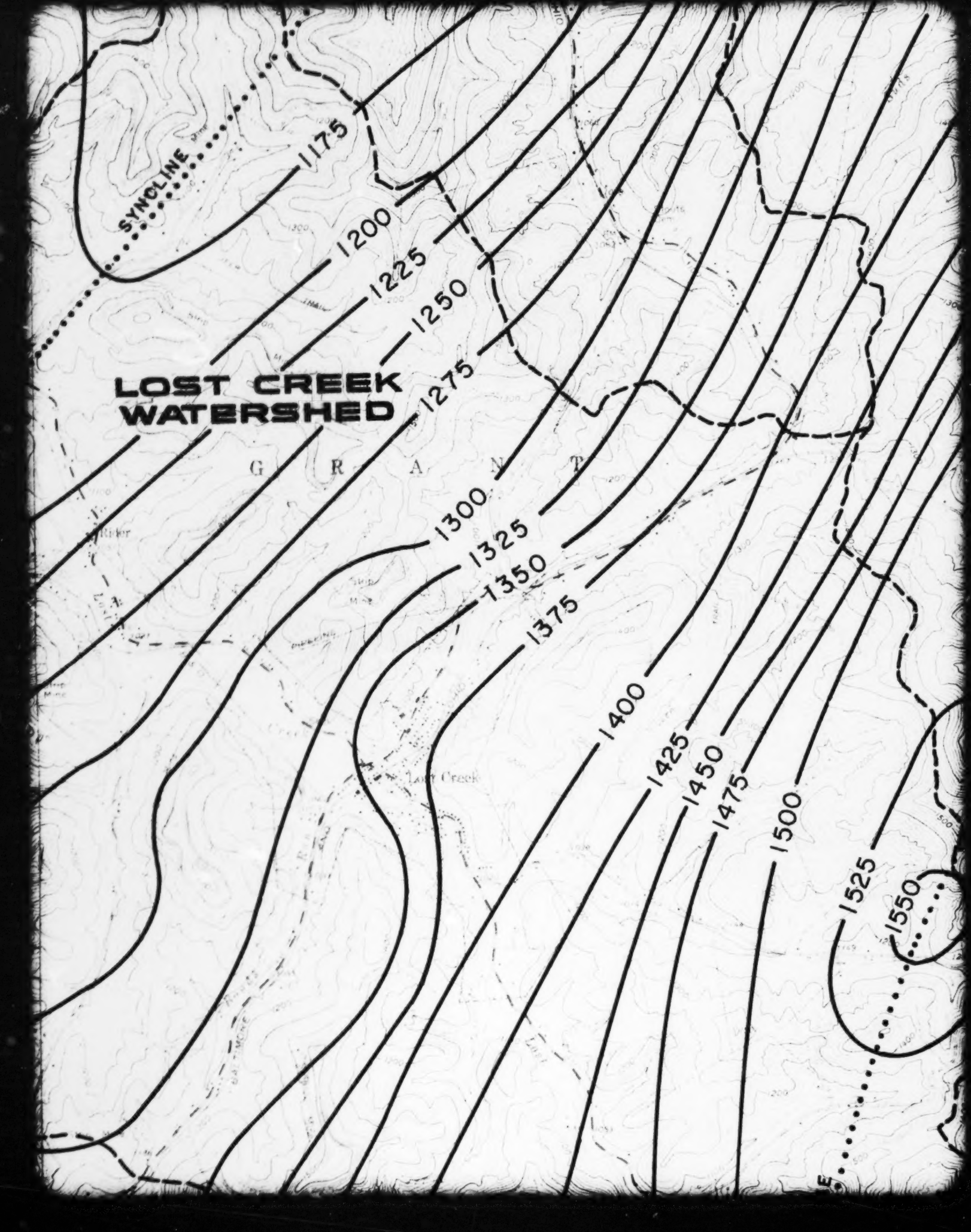
FIGURE 3

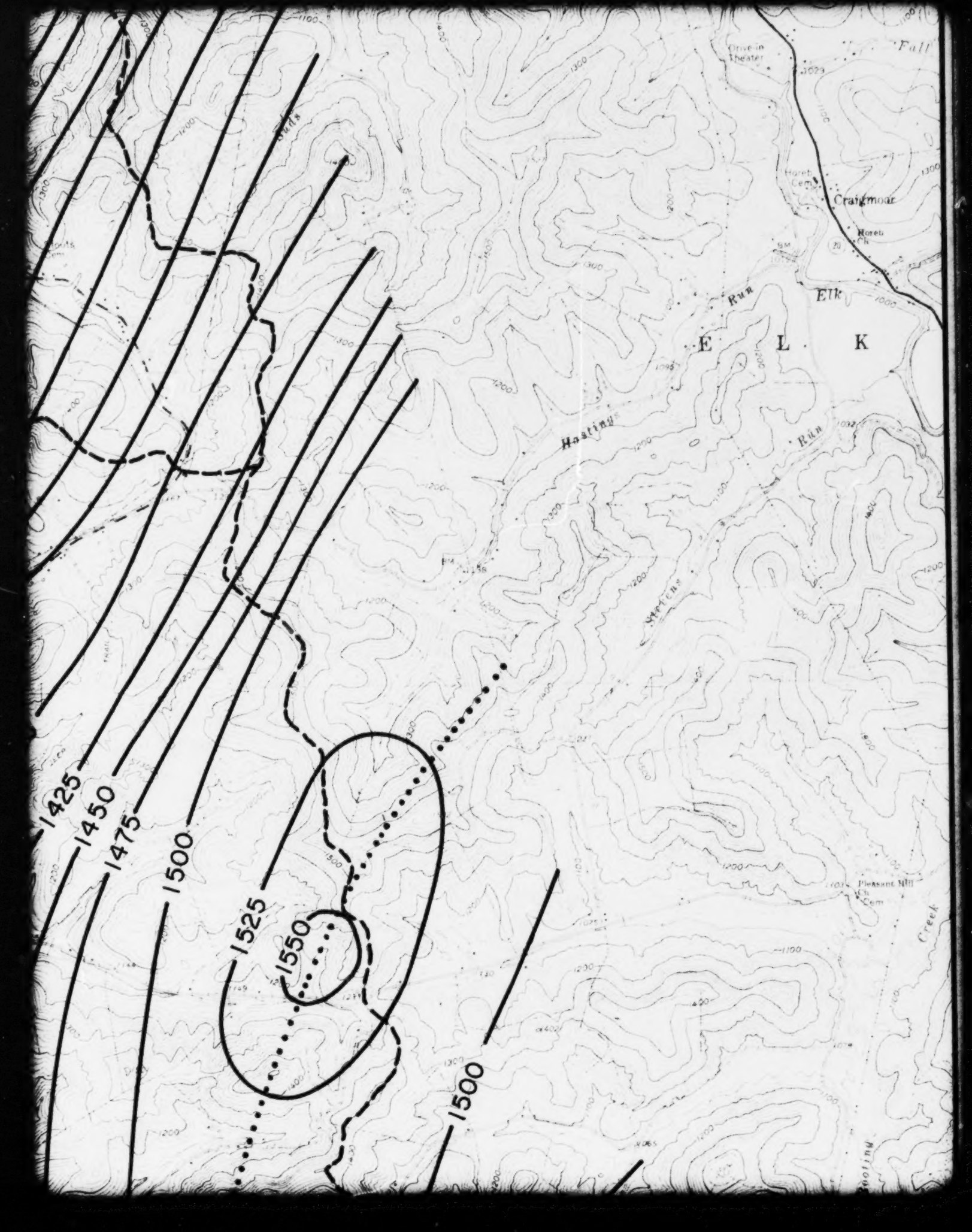
SUBSURFACE STRUCTURE ON PITTSBURGH COAL

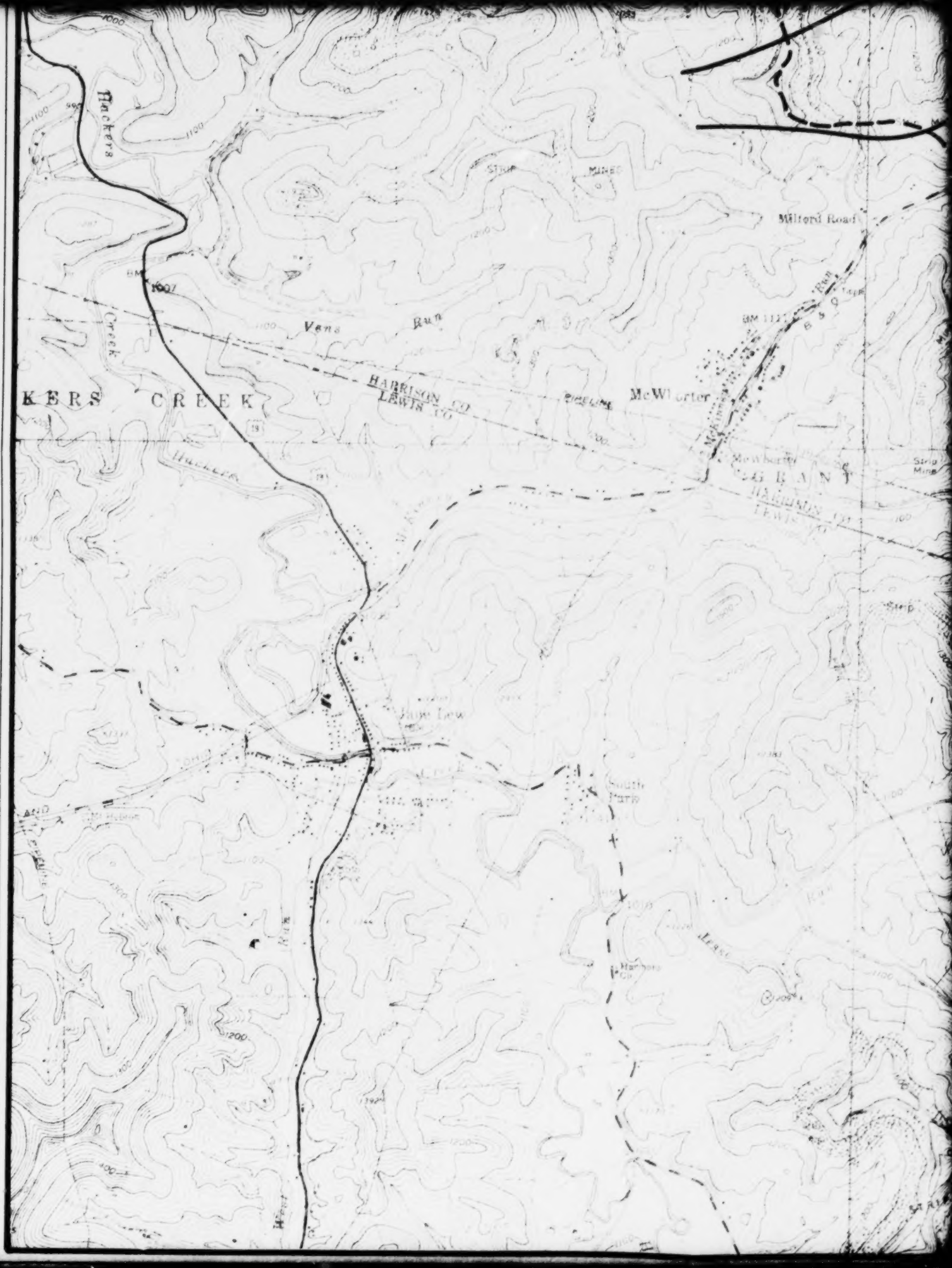
0 2000 4000 FT.

ACKENHEIL & ASSOCIATES
GEO SYSTEMS, INC. - CONSULTING ENGINEERS

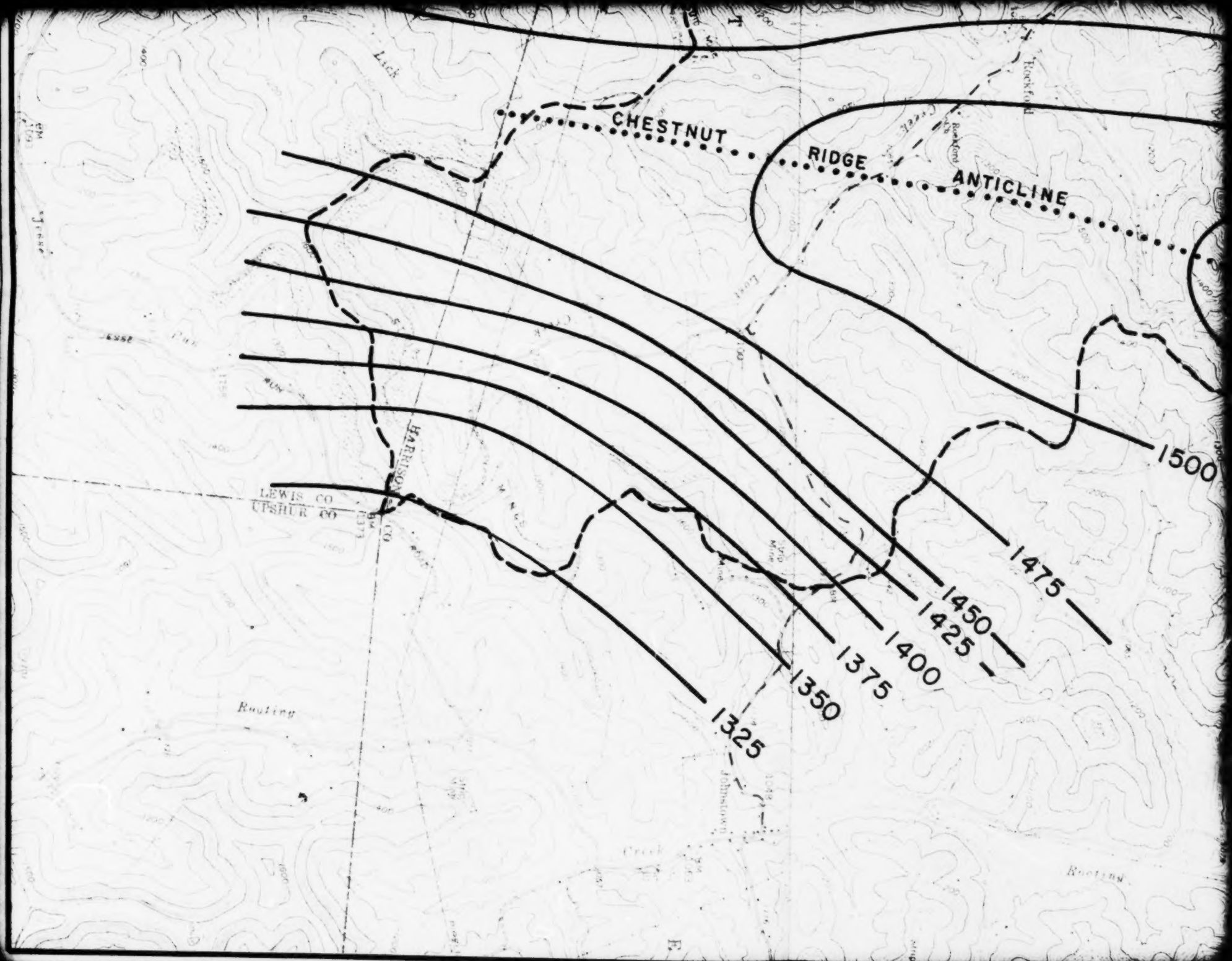

WATTERS SMITH MEMORIAL
STATE PARK
G R A N T
SHINSTON
Creek
Dutch
Flickers
Milford Road
MINES
BM 1047
BM 1005

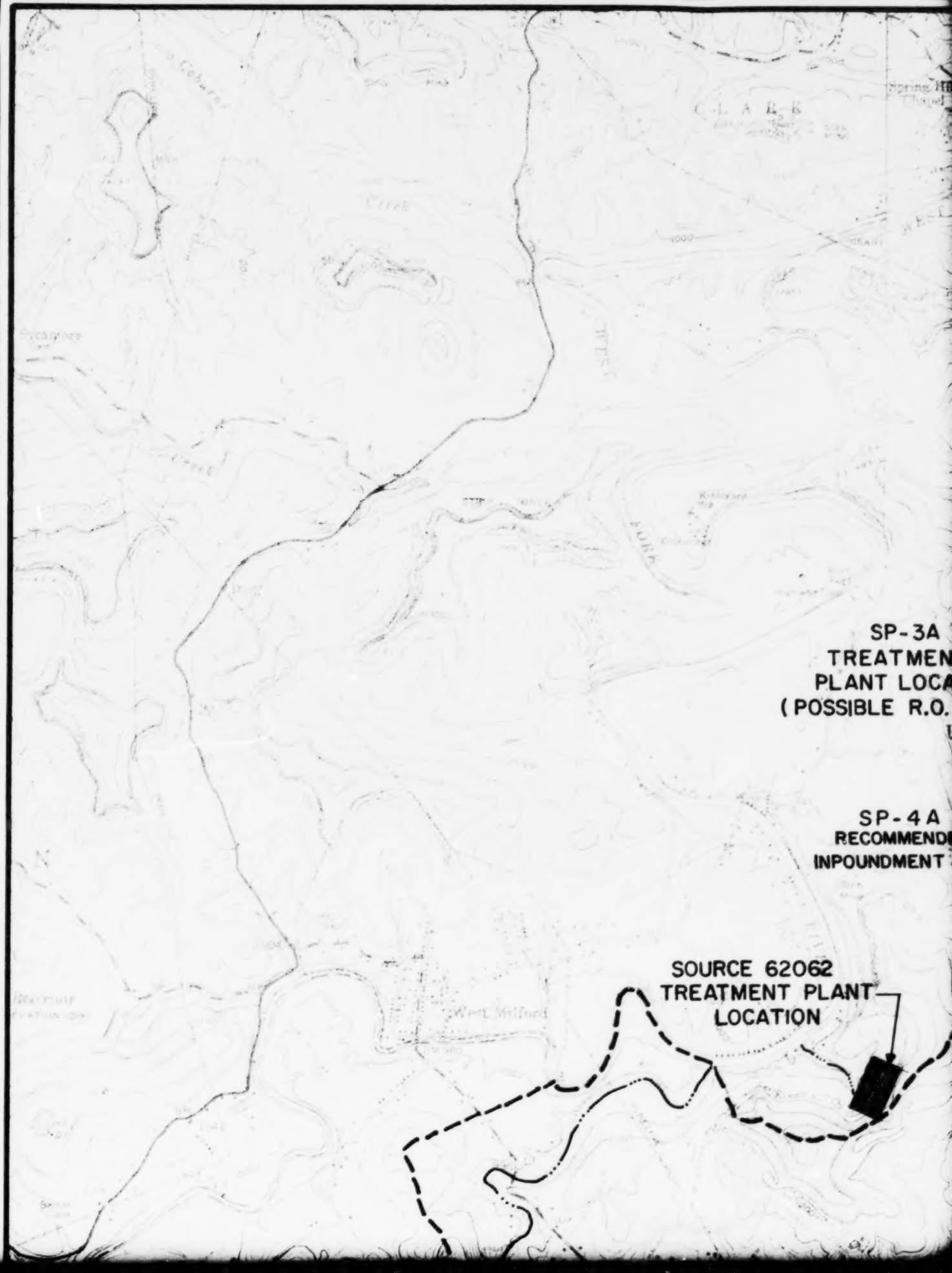

LOST CREEK
WATERSHED
SYNCLINE
1175
1200
1225
1250
1275
1300
1325
1350
1375
1400
1425
1450
1475
1500
1525
1550
G R A N T

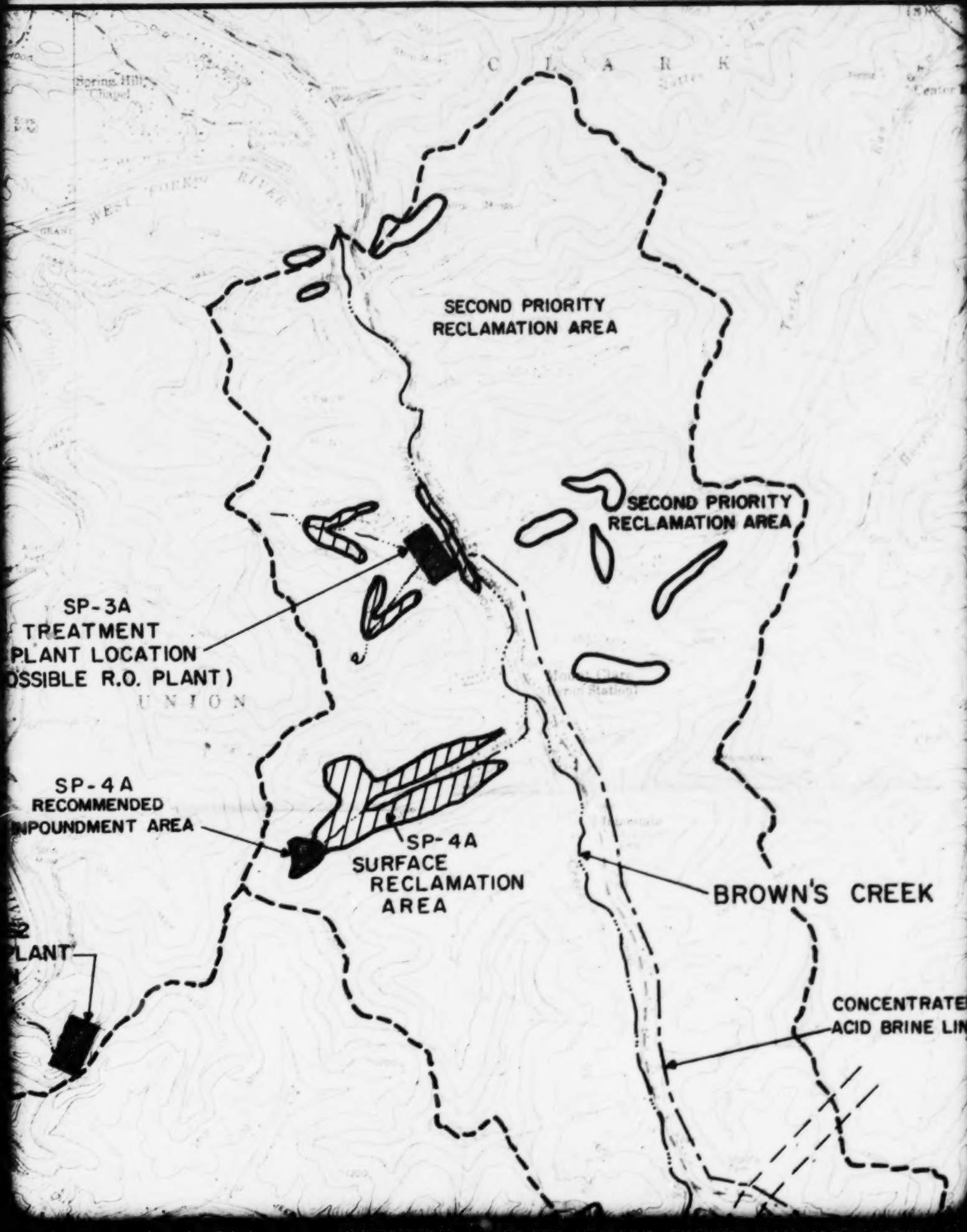

1425
1450
1475
1500
1525
1550
1500
E L K
Elk Run
Hasting Run
Craigmoor
Drive-in Theater
Horeb Cem.
Horeb Ch
Pleasant Hill Ch
Cem
Creek


Hackers
Creek
KERS CREEK
Vens Run
HARRISON CO
LEWIS CO
Milford Road
McWhorter
Newberry
GRANT
Huge Run
South Fork
Hackers Creek

Rockford
RIDGE ANTICLINE
CHESTNUT
G R A N T
HARRISON CO
LEWIS CO
PIPELINE
Lick
Run


CHESTNUT
RIDGE
ANTICLINE
1500
1475
1450
1425
1400
1375
1350
1325
LEWIS CO
UPSHUR CO
HARRISON CO
Rockford
Rockford
Ruating
Ruating
Johnstown
Creek


SP-3A
TREATMEN
PLANT LOCA
(POSSIBLE R.O.
SP-4A
RECOMMENDE
INPOUNDMENT
SOURCE 62062
TREATMENT PLANT
LOCATION


SECOND PRIORITY
RECLAMATION AREA
SECOND PRIORITY
RECLAMATION AREA
SP-3A
TREATMENT
PLANT LOCATION
OSSIBLE R.O. PLANT)
SP-4A
RECOMMENDED
NPOUNDMENT AREA
SP-4A
SURFACE
RECLAMATION
AREA
BROWN'S CREEK
LANT
CONCENTRATE
ACID BRINE LIN

EVALUATION OF POLLUTION
ABATEMENT TECHNIQUES
OF

LOST CREEK & BROWN'S CREEK WATERSHED

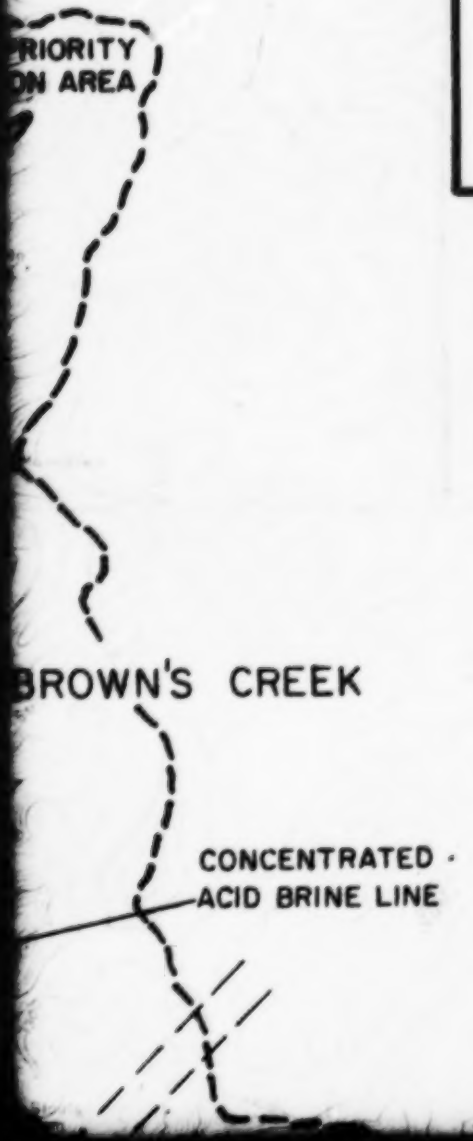
WEST VIRGINIA
FOR
APPALACHIAN REGIONAL COMMISSION

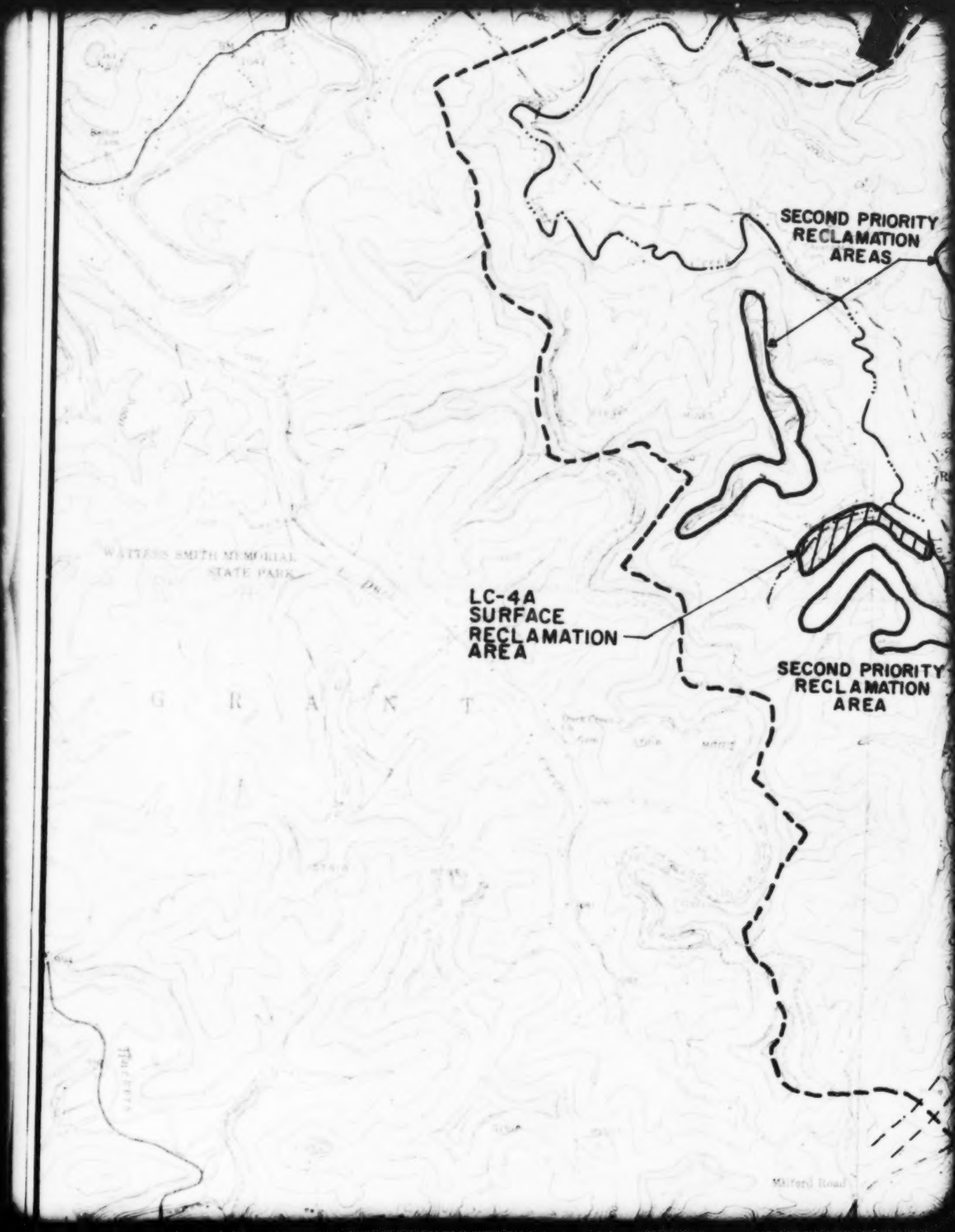
FIGURE 5

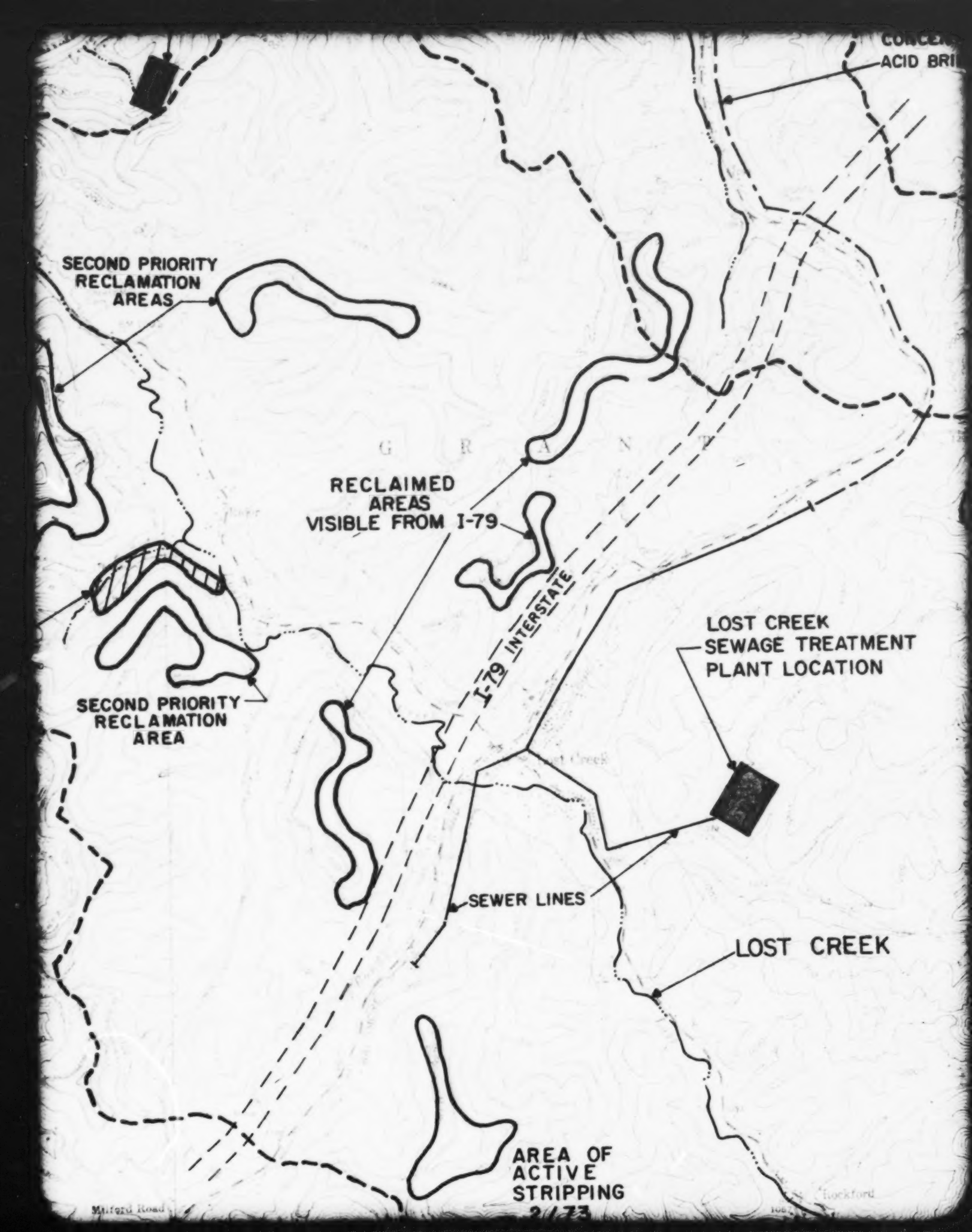
ABATEMENT LOCATIONS

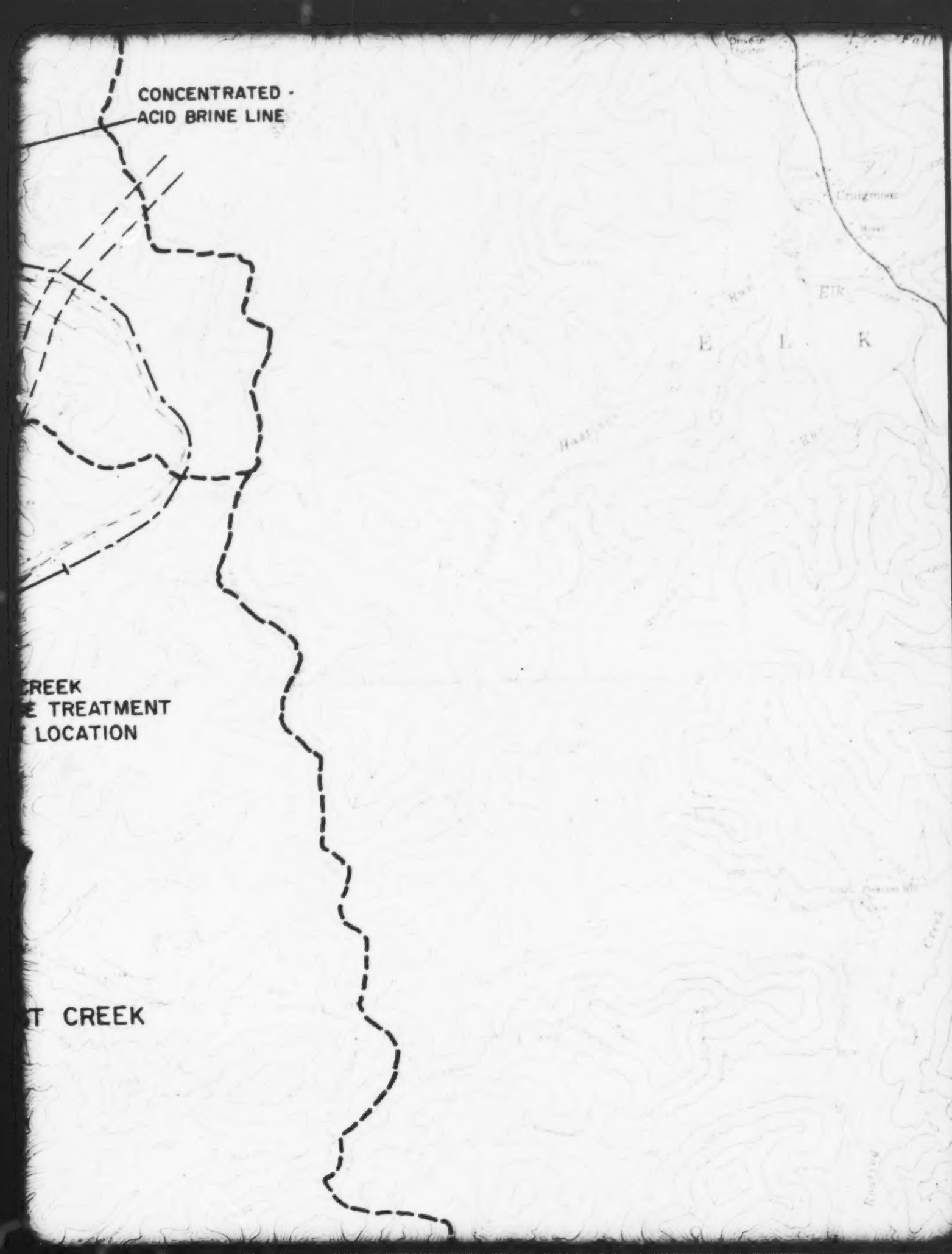
0 2000 4000 FT.

ACKENHEIL & ASSOCIATES
GEO SYSTEMS, INC. - CONSULTING ENGINEERS




SECOND PRIORITY
RECLAMATION
AREAS
LC-4A
SURFACE
RECLAMATION
AREA
SECOND PRIORITY
RECLAMATION
AREA
WATTERS SMITH MEMORIAL
STATE PARK
G R A N T
Milford Road


SECOND PRIORITY
RECLAMATION
AREAS
RECLAIMED
AREAS
VISIBLE FROM I-79
I-79 INTERSTATE
SECOND PRIORITY
RECLAMATION
AREA
LOST CREEK
SEWAGE TREATMENT
PLANT LOCATION
SEWER LINES
LOST CREEK
AREA OF
ACTIVE
STRIPPING
2/73


CONCENTRATED
ACID BRINE LINE
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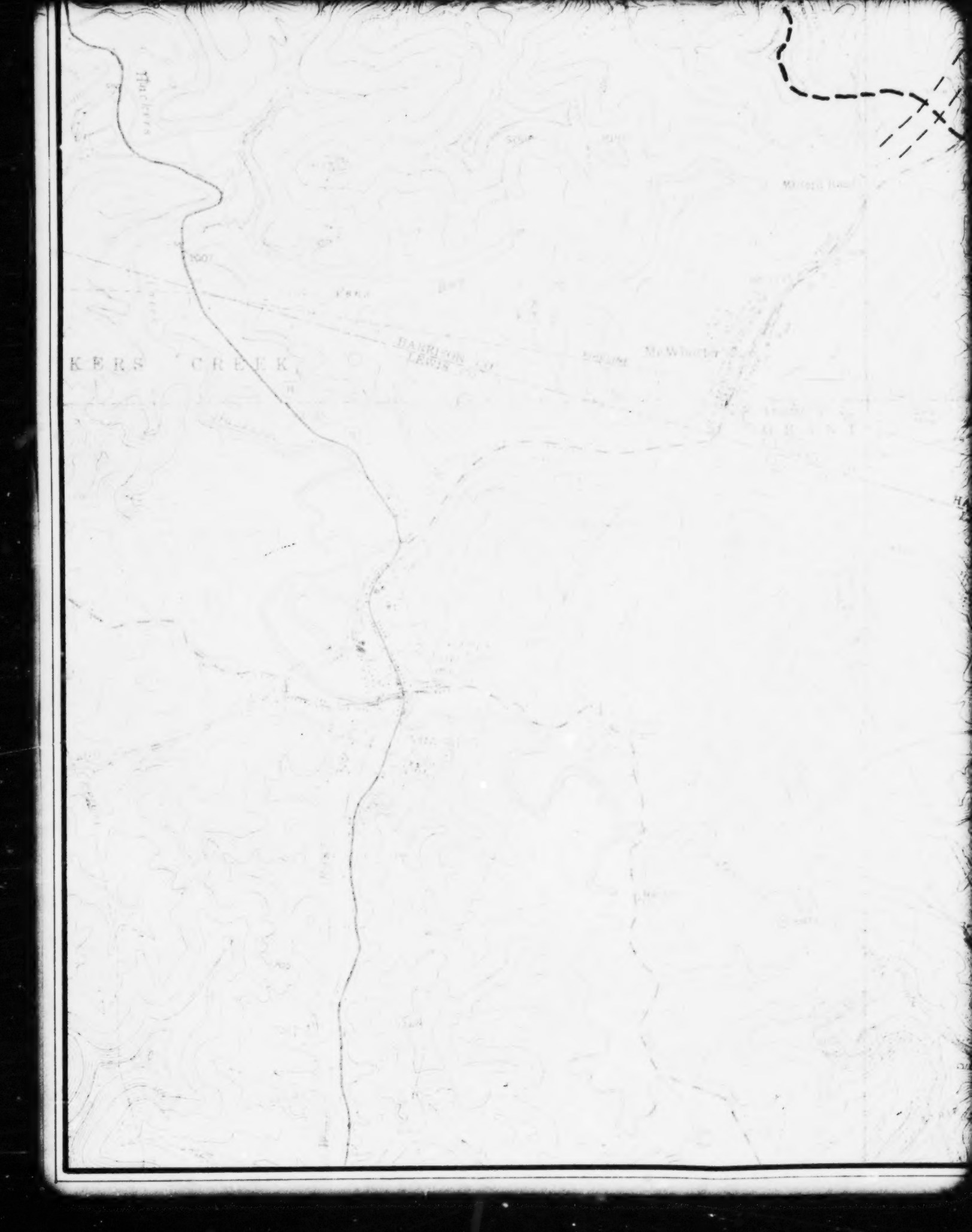
TREATMENT
LOCATION
T CREEK
E L K


KERS CREEK

AREA OF
ACTIVE
STRIPPING
2/73